Technical Report

DSWA-TR-98-15

# DECADE Systems Engineering and Integration Support

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December 1999

Prepared for:
Defense Threat Reduction Agency
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**13. ABSTRACT** *(Maximum 200 words)*

ITT Systems and Sciences Corporation (formerly Kaman Sciences)worked with the Defense Special Weapons Agency between February 1991 and March 1998, to develop the DECADE Facility. Decade is a DoD aboveground x-ray simulator located at Arnold Engineering Development Center, TN, and designed to test components for performance in harsh radiation environments such as those produced by nuclear weapons. ITT's role in DECADE was Systems Integration and Engineering Support. This included program management, test and evaluation support, user training development, and facility documentation. ITT supported the DECADE Program Management Office at HQ DSWA in the integration of five facility components: two buildings (considered a single element), the simulator (including all subsystems and associated equipment), the user data acquisition systems for testing, the shielded enclosure screen rooms (separated from the building element), and the safety and security system. ITT supported integration of all systems, focusing on form, fit, function, cost, and schedule. Subject to extensive technical risk reduction efforts by the simulator contractor and supporting technical community, Decade was still in development at the completion of this contract. A downscaled version of the simulator was being installed in the completed test structure with expectation of initial operating condition in FY 1999.

**14. SUBJECT TERMS**

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| Facility Integration and Specification Development | Meetings |
| Systems Engineering/Management | Decade Program Schedule |
| Systems Test and Evaluation | Reports and Recommendations |

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# 1. EXECUTIVE SUMMARY

## 1.1 DECADE BACKGROUND

Under this contract, ITT Systems & Sciences Corporation (formerly Kaman Sciences Corporation) has worked with the Defense Special Weapons Agency since February, 1991, on the development of the DECADE X-Ray Simulator Facility. The DECADE X-Ray Simulator Facility is a Department of Defense (DoD) aboveground x-ray simulator capable of testing components for performance in harsh radiation environments such as those produced by nuclear weapons. Components and subsystems designed for such applications as space-borne surveillance and communications and missile navigation are the main types of test articles likely to be seen at DECADE. This state-of-the-art facility is located at Arnold Engineering Development Center (AEDC) on Arnold Air Force Base, Tennessee. The name DECADE was derived from the order of magnitude increase in capability that DECADE was designed to provide over existing DoD x-ray simulation facilities. The DECADE x-ray dose-area product, a measure of merit for exposing large subsystems to environments which emulate those of nuclear weapons, approaches ten times greater than previously available.

## 1.2 ITT'S ROLE

ITT's role in the development of DECADE was the Systems Integration and Engineering Support contractor for the facility. In addition to integration and engineering support, this included program management support, test and evaluation support, user training development, and facility documentation. ITT supported the DECADE Program Management Office at DSWA in the integration and management of five major facility components: two buildings (considered as a single element), the simulator (including all subsystems and associated equipment), the user data acquisition systems for testing, the shielded enclosure screen rooms (separated from the building element), and the safety and security system. ITT was responsible for integrating all the systems, focusing on form, fit, function, cost, and schedule.

Each of these components was designed and installed by a different contractor, under the direct management of one of five Government organizations. The main DECADE building (after a design effort by Lockwood, Andrews and Newnam) and the DECADE support building were constructed by RNJ Interstate under contract to the US Army Corps of Engineers. The simulator and machine data acquisition system were designed, partially constructed, and partially installed by Physics International, Incorporated, under contract to DSWA. The user test data acquisition system was designed, constructed and installed by Sverdrup Technologies under contract to AEDC. Sandia National Laboratories also played a significant role in the design of the UDAS and coded many of the equipment drivers. The shielded enclosure was designed by MMM Design Group and constructed by Lindgren under contract to the Naval Command, Control, and Oceanographic Systems In-Service Engineering (NISE) office at Norfolk. The safety and security system was

designed by Holmes and Narver, subcontracted to ITT, and constructed and installed by MSA under contract to NISE East, Charleston.

ITT interacted with each of the Government organizations and prime contractors frequently, and although we were not in a direct contractual path with any agency except DSWA, we were expected to keep all efforts on track. Our success in accomplishing this goal was the result of the dedication and hard work of our staff and of the cooperation of all of the DECADE participants, committed from the outset to a partnership pursuing the realization of the DECADE facility goals. We were aided in no small measure by the various DECADE Program Managers and their staffs at DSWA who empowered the ITT team to gather critical information, to disseminate that information as needed, and to police the various management tools created to coordinate the DECADE development.

### 1.2.1 Facility Integration

ITT participated in all aspects of the facility design and construction. Our contract work breakdown structure addressed these functions in six areas as described below and through the rest of this final report. Facility integration included maturation of the specifications for each of the facility components and development and management of the various tools designed to ensure that the components could be assembled into a functional facility satisfying the full spectrum of requirements.

#### 1.2.1.1 Specification Development

At the start of the ITT contract, a rough set of facility requirements had been developed by DSWA and its support contractor (WJ Schaeffer Associates). These had been translated into rough specifications for the simulator component and more approximate design factors for a building to house the simulator and for a data acquisition system. ITT was intimately involved from day one in the refinement of the simulator specifications which resulted from progress on the supporting technology development programs at Physics International and Maxwell Laboratories and from the proposals ultimately submitted by each of these agencies.

As the physical attributes of the simulator became clearer, ITT worked with the architect (Lockwood, Andrews and Newnam) to evolve the building specifications to respond to both the needs of the simulator and the associated requirements of the eventual users of the facility. ITT designed, distributed, collected, and analyzed the user requirements questionnaire that supported the definition of user needs.

During the maturation of building design, for reasons that are addressed later in this report, the need for an additional support building became clear, and ITT supported the effort to prepare the specifications for that element.

The special requirements for noise-free environments for the collection and processing of test data finally resulted in the separation of the shielded enclosure element from the building, and ITT supported the effort (assigned by DSWA to AEDC) to define and coordinate approval on the detailed specifications for that element. We also took the lead

on defining the required amendments to the construction contract required to separate the shielded enclosure procurement from the building procurement.

DSWA chartered a working group consisting of ITT, SNL, AEDC, NRL, and NSWC to develop detailed specifications for the user data acquisition system, with our roles being to gather and document all inputs regarding performance requirements, to assure that user needs were satisfied and that the myriad of interfaces between the UDAS, the shielded enclosure, the building, and the simulator were consistent with successful operations.

The requirements for controlled access to the facility were developed by the ITT team. Holmes and Narver, our A&E subcontractor, had substantial experience in this aspect of facility design and produced the initial design documents. Throughout the eventual detailed design and installation of the Safety and Security System, ITT and H&N provided day-to-day oversight.

As the simulator program neared the completion of its prototype phase, it was clear that attainment of the original specifications for performance was extremely risky. ITT assisted in defining the risks to program completion and the impacts to the design, installation, and operation of each of the other DECADE elements. Cost and schedule risks led to the separation of the simulator program into a Bremsstrahlung radiation source (BRS) operational mode, to be continued, and a plasma radiation source (PRS) mode, to be handled as an option. ITT assisted in the definition of these modes and in the definition of impacts on the other subelements of the Physics International contract (for example, the auxiliary oil and water system requirements) and on the other elements of the facility.

Technology risk mitigation activities were initiated, looking for example at alternative designs for the BRS front end, and ITT was active in defining the requirements for this radiation source and for the interfaces that would be affected by changes in the design. This included identifying opportunities for downscaling support requirements for auxiliary systems, floor space, radiation safety subsystems, UDAS, etc. This activity was complicated by uncertainty as to the eventual DECADE operational configuration. As the decision to opt for only one or two simulator Quads matured, ITT provided analysis and recommendations on how best to size interfacing components, but careful to identify program impacts that might be felt if the facility were eventually to return to its original full system configuration.

When planning for the PRS design was begun anew, ITT took an active role, defining all system interface requirements and assuring that user needs were continued as a driving force in the design.

The as-built condition of the DECADE facility is the result of a continual process of evolution from approximate specifications, based on balancing what was needed with what was possible. Unlike the construction of an office, the construction of a state-of-the-art test facility requires a much more adaptive process. The evolution of technology has had a real and constant impact on the DECADE design. ITT has led the way in

assuring that new technology has been incorporated in DECADE to the extent possible, without sacrificing the basic goal of a user-friendly test facility for assuring operational defense systems in hostile nuclear weapon environments.

#### 1.2.1.2 Configuration Management/Interface Control

ITT was responsible for identifying the management tools required to maintain control of the maturing design and construction of the DECADE facility. Because none of the element contractors was directly responsible to ITT for their performance, and because of the maturing technologies being incorporated, this required several adaptations of the usual project management approaches and tools. This process was significantly improved with the assistance of an DSWA-appointed "Tiger Team" in 1993. During and following the Tiger Team, ITT was empowered to develop and implement several key project management tools, including the configuration management process and the interface control process.

##### 1.2.1.2.1 Configuration Management Process

ITT adapted a classical approach to configuration control to the DECADE program. Each of the element contractors was directed by DSWA to identify the major subelements of their programs which were to be configuration controlled. ITT characterized these elements with respect to their impact on other major DECADE elements and assigned configuration item identifications to each. ITT also proposed and, when approved by DSWA, instituted a configuration control board structure, with the board chaired by the ITT Program Manager. The configuration control process was fully documented in the DECADE Configuration Management Plan. Through the rest of the contract, ITT administered the configuration control process in accordance with this plan (although the formal procedures of the Configuration Control Board were exercised only twice).

##### 1.2.1.2.2 Interface Control Document

At the outset of our contract, ITT had identified the lack of direct control of the various element contractors as a major risk factor to our successful integration of DECADE. Our proposal was to achieve control, in the absence of contractual obligations, through careful identification, definition, and control of the interfaces between the DECADE elements. Definition of those interfaces, as well as of internal interfaces with substantial potential to impact subsystem operation, was undertaken with the full cooperation and support of the element contractors and the managing Government agencies. The Partnering agreement, instituted by the Army Corps of Engineers, greatly mitigated any problems we might have encountered in instituting interface control through the Interface Control Document (ICD). As the definition of each element matured, ITT amended the ICD, adding pages for each new interface, defining the technical details of the interface and identifying the personnel responsible for the components on each side of the interface.

As the definition of the building and simulator matured, parts of each system were pulled out as separate elements. The PRS components were subtracted from the simulator and

subsequently reconsidered as a separate potential DECADE element. The shielded enclosure and the Safety and Security System were separated from the building element and redefined as separate elements in themselves. When each of these actions took place, ITT augmented the ICD to recognize this new definition of interfaces external to each element. Pages were added to the ICD to maintain control over the pieces of the facility and to help ensure the operation of the ensemble, once integrated.

The establishment and maintenance of the ICD was one of ITT's most important contributions to the integration of the DECADE facility. The ICD has become the mainstay of the DECADE project, and promises to remain a key operational tool for AEDC throughout the life of the DECADE facility.

### 1.2.2 Systems Engineering

The second major function ITT performed during the DECADE project was as systems engineer, studying and resolving key technical issues which arose during DECADE development. In accordance with our work breakdown structure, we have grouped these efforts into various disciplinary functions described here and in the detailed sections of this report. All of these activities shared the common attribute of being essential to the continued control of program risk – technical performance, schedule, or cost. Examples of each of the activities are contained in the following sections. A listing of the reports and memoranda we produced which contained significant results of our engineering analyses and recommendation for action is included in Appendix C.

#### 1.2.2.1 Trade-Off Analyses

Trade-off analyses were carried out when it appeared that alternative approaches might have different levels of risk mitigation or program advantage. ITT gathered the available data on the alternative approaches, weighed the likely impacts on completion of the DECADE facility, and recommended the approach to follow. One significant trade-off study involved the choice of software for the user data acquisition system. While preparing the system specifications, SNL became a strong advocate for the use of commercial software provided by Voss, Incorporated, which was one of their suppliers. ITT provided an independent assessment of the Voss software and of the level of effort required to adapt this software to DECADE requirements. Our evaluation and recommendation to DSWA to rely instead on new software to be developed by AEDC and SNL was accepted, based on long term issues of cost and access to proprietary design and maintenance information.

#### 1.2.2.2 Life Cycle Cost Studies

Life-cycle cost analyses were performed to support prudent management decisions among alternatives approaches. Life-cycle cost was not frequently the driving issue in DECADE, but in the case of the design of a system to provide cryogens for cooling the vacuum pumping components of the simulator and the user test chamber, cost was the prevalent factor. ITT analyzed the volume of cryogens needed to support test operations and recommended that manual techniques would save substantially over automated

techniques. We reported this finding in a report to DSWA and AEDC and recommended that DECADE rely on manual replenishment of system cryogen dewars. AEDC took exception to our recommendation, believing that the convenience of an automated system would benefit long-term operations. ITT supported AEDC as they repeated our life-cycle cost analysis and ultimately supported the DSWA decision to accept our recommendation. Cost savings to the DECADE program were calculated to exceed several hundreds of thousands of dollars in installation costs, an amount unlikely to be offset by estimated labor costs savings during the life of the system.

#### 1.2.2.3 Safety Analysis

Safety Hazard Analyses, assessing safety risks to personnel, equipment, and production downtime, were a required deliverable for the simulator and UDAS elements. ITT supported this activity by reviewing each submission and ensuring that all required elements of such analyses were completed. We also initiated a system-level safety analysis to ensure that all hazards resulting from operation of the facility as a whole would be mitigated. We relied heavily on the expertise of Holmes and Narver, our Architect and Engineering subcontractor, to perform this function. ITT will assist AEDC facility personnel in the completion of the system safety analysis.

#### 1.2.2.4 Design Integrity Analyses

As system engineer, ITT had the responsibility to ensure that facility designs were consistent with the requirements established for facility performance. Further, we put into place procedures to ensure that once designs were evaluated against requirements, the construction of each of the elements was completed in a manner to ensure continuance of the design integrity. Performance of the test cell with regard to radiation containment was the subject of many ITT design analyses. ITT performed independent analyses of the radiation environment within the test cell, as described in the next section, and then verified the design of the test cell walls, ceiling, and access routes to ensure the created radiation environment exterior to the test cell would not exceed regulated radiation levels. ITT's analysis of the test cell ceiling saved over $100,000 in construction costs by lowering the thickness required from 30 inches to 19 inches. This was driven in large part by an innovative analysis of the back-scattered radiation (sky shine).

#### 1.2.2.5 Radiation Environment

Central to the prediction of effectiveness of the test cell shielding, the radiation-induced noise performance of test cables, and the survivability of the test instrumentation was a traceable prediction of the radiation environment which will be created by the simulator. This was the subject of several independent analyses provided by ITT's Colorado Springs technical staff under the leadership of Walt Hardwick. These analyses were compared with the planning calculations of the Primex Physics International (PPI; formerly Physics International), staff to establish confidence in the likely mapping of radiation intensity at several critical locations. Reports were submitted on the required wall and ceiling thickness, the design of the mazes protecting the rear entry points, the

effects of voids in the walls, the requirements for filling intentional and unintentional holes in the walls, the performance of the cable trays in the test platform, the survivability of the overhead crane electronics, the weight of shielding for cable connections from the test chamber to the cable trays, the likelihood of noise in instruments in the administrative areas, the design effectiveness of the moving shield doors, and the predicted uniformity of the radiation patterns at various locations in the test volume.

#### 1.2.2.6 Quantitative Risk Analysis

One of the more important management tools adapted by ITT for use by the PMO was the Quantitative Risk Analysis methodology, based on Air Force Pamphlet 63-101. This methodology was generally developed to guide the development of military equipment items rather than for unique test facilities. ITT, under the leadership of Dennis Jones, our QRA specialist, first applied this methodology to the various elements of the DECADE facility at the element and the sub-element level and provided recommendations to the PMO on changing priorities of several programs to reflect better risk management. Then, Eugene Shaulis, the CM specialist on the ITT Alexandria staff, developed a unique adaptation of the methodology to evaluate and mitigate risks associated with incomplete interface specifications, an especially critical element of systems integration involving the DECADE interface control methodology. These analyses formed the basis of a set of QRA reports which ITT provided to DSWA and the DECADE community.

### 1.2.3 Program Management

#### 1.2.3.1 Administrative Support

ITT assisted the PMO in developing progress briefing materials; assisted in the contract deliberations for the simulator, shielded enclosure, and safety and security system contractors; and participated in weekly business meetings at the Agency in which many of the topics included internal DSWA reporting requirements levied on the PMO. We developed the Program Manager's Handbook (a full compilation of DECADE briefings and descriptions, historical data, Work Breakdown Structures, program and element schedules, meeting minutes, etc.) and hosted many business and technical meetings, including the Source Selection Evaluation Board meetings for the simulator contract, in our facility in Alexandria.

As the program matured, ITT's administrative support function became more the center piece of technical and programmatic communication throughout the DECADE program.

ITT drafted agendas and minutes of the Program Management Review meetings, and distributed them to the DECADE community. We hosted and participated in all working groups established to track performance in the design and construction of the various DECADE elements. After 1994, the number of these working groups were scaled back

and the Integration and Test Working Group (ITWG) became the mainstay of program review and communication. ITT routinely supported the administration of ITWG meetings.

Meeting minutes and the DECADE Action Item system became the centerpiece for program activity documentation and control. ITT produced all of these documents throughout the contract period.

#### 1.2.3.2 Schedule Management

The DECADE Master Schedule database was designed, populated, and maintained by the ITT staff in Alexandria, primarily by Michelle Undercoffer. ITT tasked element contractors (and many of the supporting Government agencies) to provide schedule information for this database. Our analyses of the data was routinely presented at PMRs and ITWG meetings. This data became the main tool for discovering and mitigating interference between elements and for highlighting schedule slippages within the program.

#### 1.2.3.3 Technical Liaison

ITT's role as technical liaison grew directly from our central position in the program. To expedite communication of information from the various element contractors and Government organizations, ITT had to maintain technical cognizance of the activities in all areas and provide recommendations to the PMO on issues. The primary technical tool used by the PMO was the Technical Advisory Group (TAG). The ITT Program Manager was a regular member of the TAG.

### 1.2.4 System Test And Evaluation Support

System Test and Evaluation Support comprised all activities aimed at official acceptance of the various DECADE elements. In addition, ITT followed a philosophy of adequate testing of the ensemble of elements to ensure that DECADE was fully integrated. Throughout the program, we maintained oversight of element test activities to ensure that each element contractor verified its deliverables met all defined requirements in consonance with the Interface Control Document. We frequently reviewed the ICD to ensure that interfaces were defined in such a way that adherence to requirements would provide the maximum likelihood that the elements would work together without the need for additional adaptation and testing. It was this strict adherence to interface control that we believed would enable DECADE operation without excessive, expensive, and time consuming facility testing after completion of construction and installation of all elements. As this report is written, we are unable to verify completely that this philosophy has accomplished its goal, since the simulator is yet to be completed. The completion of the shielded enclosure, the safety and security system and User Data Acquisition System appear to have validated our approach, however, in that careful acceptance testing of each of those elements succeeded in verifying their operation in the facility without the need for additional ensemble testing.

#### 1.2.4.1 Management Plan

The Management Plan for Acceptance of the DECADE Facility was the document that embodied the test and evaluation philosophy which ITT implemented. The plan was developed by ITT under the leadership of Gary Brock and approved by DSWA and AEDC in November, 1994. The Management Plan established a formal process for the acceptance of each DECADE element involving preparation and approval of test plans, planning and execution of reviews, and official documentation of all acceptance activities. This document has become the official road-map from element design to initial operational capability as a fully integrated component of the DECADE facility.

#### 1.2.4.2 Transition Plans

Because the DECADE buildings required an additional transfer of ownership and responsibility within the Government (from the Army Corps of Engineers to DSWA to AEDC), ITT developed the Building Transition Plan and the Support Building Transition Plan to expedite and document that process. The Transition Plans were approved by DSWA in February, 1995. The processes embodied in the Transition Plans allowed greater participation of DSWA and AEDC in the inspection and acceptance of the buildings than the normal Corps processes. In this way, ITT lessened the risk of facility shortcomings impeding the immediate utility of the buildings to support DECADE operations. This was especially critical at DECADE since AEDC took partial beneficial occupancy of parts of the buildings while construction was still progressing on other parts.

To document that the building satisfied all external interface requirements identified in the Interface Control Document, ITT developed the On-site Building Verification Requirements (OBVR) database. This database tracked 48 items requiring special attention since they were not associated with any planned demonstrations of Building system performance. Each of the items was independently verified by either ITT or AEDC on-site personnel prior to Building acceptance.

Then to document and track resolution of each deficiency noted during walk-through inspections preliminary to beneficial occupancy of areas in the Building, ITT developed "punchlists." Each of the items on the punchlists (construction deficiencies, testing failures, or training shortfalls) was tracked from discovery through resolution. The punchlists became the core management tool guiding final building acceptance in January and February 1996. The listing of items on the punchlists was the main topic of a weekly telephone conference between DSWA, AEDC, and ITT (Alexandria, Tullahoma and Colorado Springs) and was reported by ITT at each ITWG meeting. The final punchlist became part of the final all-inclusive deficiency list for the Building in August, 1996.

### 1.2.5 User Training Development

The definition of ITT's User Training responsibilities changed markedly during the execution of this contract. Originally, ITT was to prepare documentation that would help prepare testers for their first operations at DECADE. An Operations Handbook, in both

hard copy and computerized training versions, and an Operations Videotape were the products proposed to perform this function. As program completion slipped and resources on this contract were stretched, this set of products was reevaluated.

In 1994, DSWA directed that ITT develop, as an alternative to the videotape, a brochure describing DECADE to be distributed at the 1995 HEART Conference. That brochure is shown in Figures 1-1 and 1-2 at the end of this Executive Summary.

The requirements for the Operations Handbooks were also been redefined. ITT prepared and delivered a concise *User's Guide for the DECADE Radiation Facilities at AEDC* to familiarize potential testers with the facility. This document will require DSWA/AEDC to complete details when available.

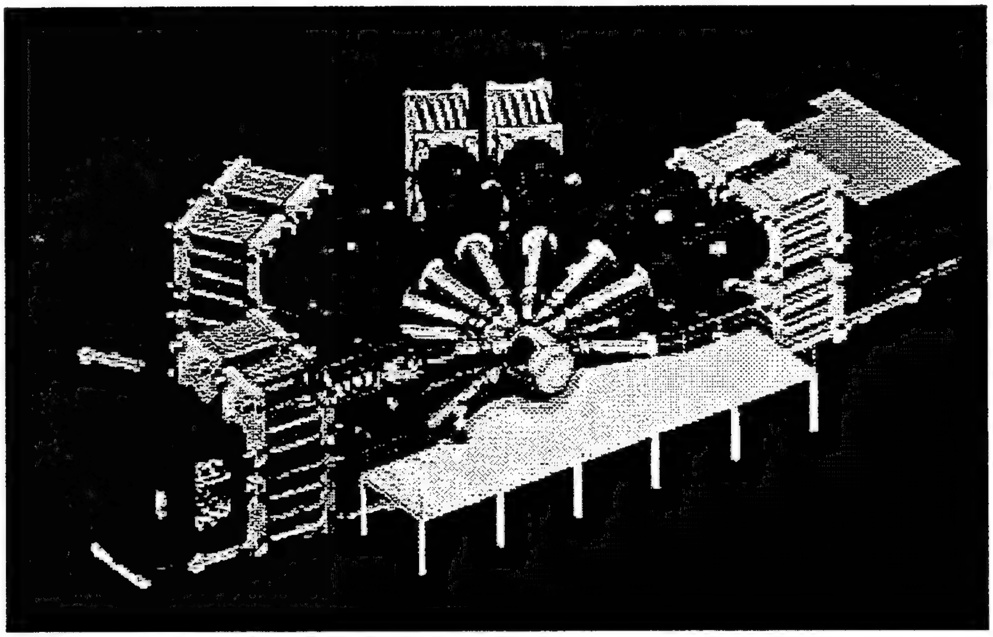
### 1.2.6 Technical Publications & Data

ITT produced two documents under the Technical Publications task. They were the User Requirements Questionnaire Report, delivered in 1991, and the Facility Operations and Maintenance (O&M) Manual, delivered in 1996. The User Questionnaire was circulated to 173 cognizant organizations and consisted of 100 questions addressing every area of user support at DECADE. Answers were received from 10% of the survey. Answers were analyzed and became one of the guiding documents in establishing floor space and other user support requirements in the final facility specifications.

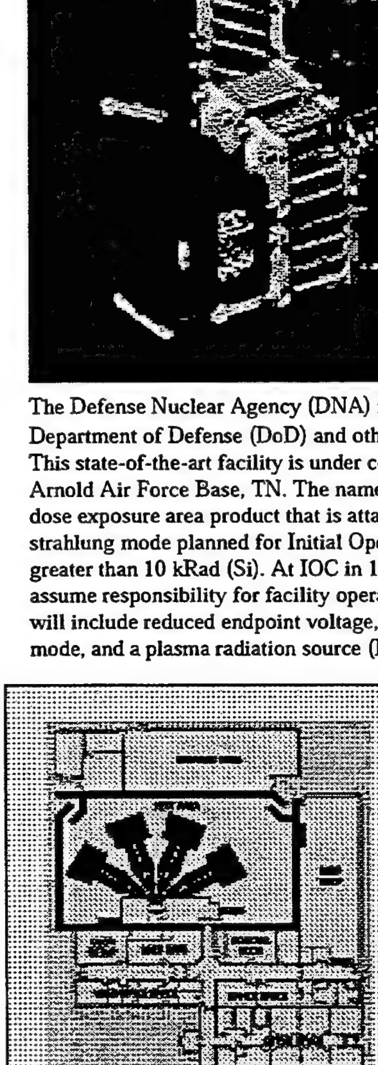
ITT also collected O&M data and publications on all DECADE elements and components. These documents were catalogued and maintained by ITT as a reference library at AEDC until 1996, when they were officially turned over to the AEDC DECADE operations staff. Before turnover, ITT analyzed each set of manuals for warranty and training information, and submitted that listing to DSWA and AEDC with our recommendations for action to extend warranties and to claim all training support available to the Government. At the end of 1996, we provided DSWA and AEDC, as a Program deliverable, a complete catalogue listing of all available O&M manuals, in 1997, we reviewed the documentation of the completed UDAS Element and recommended that the UDAS Software Operations Manual be split into an operator's manual and an experimenter's manual. This would permit the experimenter to have a quick reference and training tool to perform data manipulation. AEDC is considering the recommendation for implementation when the first user arrives.

# DECADE WORLD'S LARGEST X-RAY SIMULATION FACILITY

Defense Nuclear Agency



The Defense Nuclear Agency (DNA) is building the DECADE X-ray Facility to verify that critical Department of Defense (DoD) and other systems can perform their missions in harsh radiation environments. This state-of-the-art facility is under construction at Arnold Engineering Development Center (AEDC) on Arnold Air Force Base, TN. The name DECADE arose from the goal of an order of magnitude increase in the dose exposure area product that is attainable at existing DoD facilities. At present, the large area bremsstrahlung mode planned for Initial Operating Capability (IOC) will have an exposure area of 1 $m^2$ and dose of greater than 10 kRad (Si). At IOC in 1996, DECADE will be turned over to the Air Force (AEDC), which will assume responsibility for facility operations and maintenance. Planned Product Performance Improvements will include reduced endpoint voltage, reduced pulsewidth, multiple pulses, a small area bremsstrahlung mode, and a plasma radiation source (PRS) capability that will include Al and Ar radiation lines.



The Facility is designed with a number of user-oriented features: 1,000 ft of floor space for user data acquisition needs, dedicated test setup area, user shop, and classified testing capability, along with data analysis and storage capabilities.

DECADE will be the only DoD aboveground x-ray simulator capable of testing entire large-area operating electronic ensembles such as satellite surveillance, communication, and missile navigation sub-systems. The primary purpose of this premier test facility is to provide a user-friendly systems developer test capability; however, the simulator may also be used to develop and advance technologies for x-ray simulators. The simulator will produce 30-40 terawatts of power for a period of 40-50 nanoseconds. The energy required to produce the x-rays is stored in the Marx capacitor banks at the rear of the simulator. The Marx banks are discharged through closing switches, pulse forming lines, magnetically insulated transmission lines (MITL), and a plasma opening switch (POS). Upon opening of the POS, the resulting energy pulse is derived from the energy being released to the diode source plate through the downstream MITL. The diode converts the electrical energy to x-rays through the bremsstrahlung process. These x-rays expose the test article, which is located in a vacuum chamber or ambient conditions. Test articles up to 1.5 m diameter and 2 m length can be accommodated in the vacuum chamber; larger test articles may be tested at ambient conditions.

**Figure 1-1. DECADE Brochure (front)**

## Defense Nuclear Agency DECADE X-ray Simulator Characteristics

**Radiation Source Specifications:**

| Source | Average Yield*/Dose | U** | Area | Pulse Width FWHM | Average Peak Diode Voltage not to exceed |
|---|---|---|---|---|---|
| Bremsstrahlung | 10-13 kRad(Si) | 2.0 | 10,000 $cm^2$ | $\leq$ 50 ns | 1.5 MV |

* Area-weighted average

** Uniformity (U) is defined as the ratio of Maximum Radiation to Minimum Radiation over the total area measured in a rectangle with an Aspect Ration less than or equal to 1.2:1.0

**Fully Rated Operations:** The facility has the capability to support three shots a day. It can be configured to accommodate various security levels including sensitive compartmented information.

**User Data Acquisition System (UDAS):** The data storage and management system capability is sufficient to record, analyze, and archive collected data. For personal computer hookup, the UDAS network design supports both IBM and Macintosh computers with an Ethernet connection. The UDAS will use DEC Pathworks networking software, which supports Windows for Work Groups, Windows-NT, DECnet, TCP/IP, and Appletalk.

**UDAS User workstation Hardware:**

- DEC 2100/500MP "SABLE"
- 64 MBytes memory
- 2 GBytes disk storage
- 20 GByte linear tape, CD-ROM, 4 mm DAT tape, 9 track tape
- Two weeks on-line archival of test data

**UDAS Software:**

- VMS, Windows-NT, OSF/1 operating systems
- FORTRAN and C compilers and optimizing pre-compilers
- DECnet, TCP/IP, NFS Network Software

**Security:**

- C2 rated operating system
- Classified and unclassified removable disks

**Instrumentation:**

- Initial instrument setup in less than four hours
- Processed data available in 20 minutes after shot
- Quick look within five minutes to permit planning for next shot parameters
- Noise floor ~10 mV peak during pulse, 10 μV after 100 μs
- 148 channels available at IOC (expansion to 350 is planned)

**Equipment Parameters:**

| Analog Bandwidth | Sampling Rate (samples/sec) | Number of Channels |
|---|---|---|
| DC — 1 GHz | 4 G | 5 |
| DC — 400 MHz | 2 G | 47 |
| DC — 100 MHz | 500 M | 32 |
| DC — 10 MHz | 50 M | 32 |
| DC — 100 KHz | 500 K | 32 |

**Direct Digital Data Recording Systems (DRS):** Two complete systems are available:

- Ethernet interface for communication with UDAS network
- Acquisition of 64 bit digital data at 12.5 MHz data rate
- 512 Mbytes of data memory
- Inputs for gating (trigger) signal and fiducial signal
- Data downloaded via DECADE computer network

**Test Support:** AEDC is a full service test complex with vast experience in space, aeromechanical and propulsion testing. An established test infrastructure permits excellent customer interactions ranging from pre-test analysis to test planning to evaluation of test data. Fiber optic links are connected to AEDC Convex and Cray mainframes for additional computational resources. Various codes are available to perform analysis of circuits, pulse power, radiation sources, and effects on electronics.

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**Figure 1-2. DECADE Brochure (back)**

# 2. INTRODUCTION

## 2.1 DECADE PROGRAM OVERVIEW

The Defense Special Weapons Agency (DSWA) is developing a class of pulsed power radiation simulators which can simulate the x-ray environment caused by nuclear weapons to evaluate the survivability and performance of electronic assemblies and optical structures under various threat scenarios. DECADE will help supplant the historic reliance on Under Ground Test Facilities to conduct nuclear hardening tests. The DECADE simulator will be capable of testing ensembles of electronics, optics, and other military hardware to JCS threat levels with good fidelity and high shot rate. It is designed to be capable of 3 shots per day, 360 shots per year.

The DECADE simulator was designed from the ground up as a user testing oriented x-ray simulator. The user orientation of DECADE provides a test facility where the tester can conduct test with state-of-the-art equipment with relative ease. The flexibility of the facility provides the user connectivity to existing equipment or to other specialized equipment brought in by the tester. It supports testing classified systems within a secure environment. Located at Arnold Engineering Development Center in Tullahoma, Tennessee, the facility will contain everything a tester will need to conduct a test.

## 2.2 ITT'S GOALS AND OBJECTIVES

The objective of this contract was to support the DSWA's DECADE Program Management Office in performing systems engineering and systems integration. This effort entailed the collection, analysis, and synthesis of information to ensure the DECADE X-ray Facility was designed and built to meet the needs of the nuclear testing community within certain programmatic constraints. Due to technical difficulties associated with the attainable level of radiation from the prototype DECADE simulator module, the overall program was redirected to solving design alterations and technical risk reduction. This has delayed completion of the facility and necessitated several reevaluations of the program. ITT has assisted DSWA during this process.

This program required interactions between several Government organizations and DECADE contractors. The primary Government agencies supporting DSWA with the DECADE program were:

- the Air Force Arnold Engineering Development Center, which hosts and operates DECADE facility;
- the US Army Corps of Engineers, responsible for monitoring design and construction of the building;
- the Naval Command, Control, and Oceanographic Systems In-Service Engineering (NISE) office,
- NISE East (Norfolk Detachment), responsible for design and fabrication of the shielded enclosure for the data acquisition systems, and

- NISE East (Charleston), responsible for the design and fabrication of the safety and security system for the entire building and the Sensitive Compartmented Information Facility (SCIF) environment.

The primary contractors involved included:

- Lockwood, Andrews, and Newnam, an architectural and engineering (A&E) contractor to design the building;
- RNJ Interstate, a construction contractor to construct the building;
- Primex Physics International (PPI), a radiation source contractor to design and build the x-ray source and its associated diagnostics;
- Sverdrup Technologies, the AEDC base support contractor, to design and install a user data acquisition system;
- Lindgren Corporation and MMM Design Group, to design and construct, respectively, the shielded enclosure; and
- Management Systems Associates, to install the Safety and Security System. See Figure 2-1.

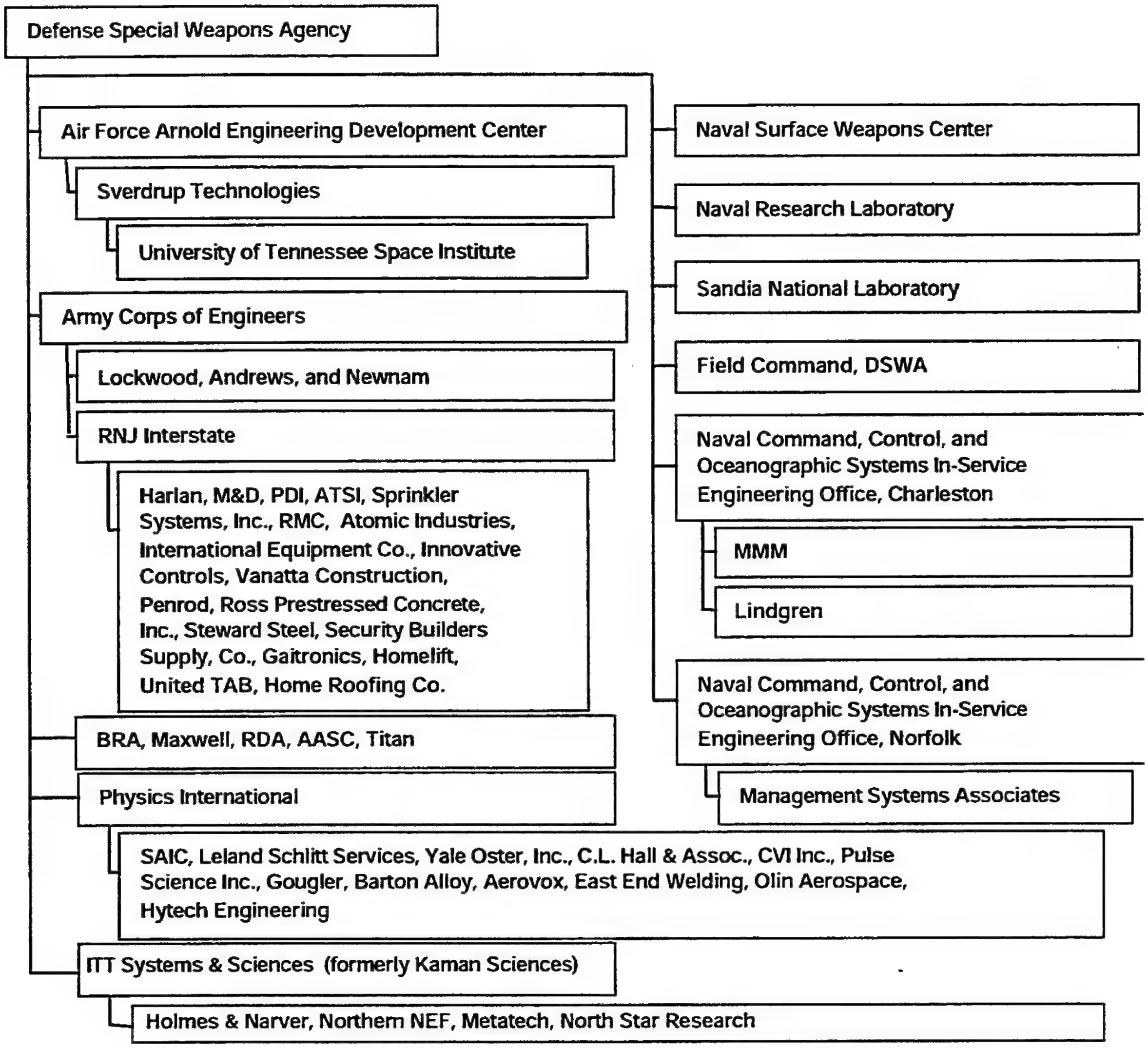



**Figure 2-1. DECADE Organizations**

ITT emphasis was placed on the system level issues with the project user in mind while providing the PMO program management guidance. This effort began with the selection of a building design and simulator contractor and was originally intended to continue through initial operational capability (IOC). Program delays made attainment of IOC impossible during the life of this contract.

It was ITT's role to provide systems integration and management support to the PMO office for the integration of the DECADE facility. This includes the integration support, systems engineering support, program management support, test and evaluation support, user training development, and documentation of the complete program. ITT established a team capable of providing DSWA the systems integration and program management to meet the state of the art goal for DECADE.

ITT's goal has been to ensure that valid technical and functional requirements are met and that established controls work in consonance with the developer's needs and are compliant with appropriate regulations. ITT and its team members have been fully committed to the DSWA goal of an integrated operational DECADE facility which meets all the specification outlined in the beginning of the program. Attainment of this goal has required that ITT maintain strong lines of communication and coordination with nearly every organization involved in the DECADE program.

## 2.3 MANAGEMENT STRUCTURE

ITT originally formed a team with Holmes & Narver (H&N), Metatech, and Northern NEF, with ITT as the prime contractor. H&N is one of the ten largest A&E firms in the United States. The Albuquerque, New Mexico, office has provided independent architectural and engineering services as the needs arose. Metatech is a small business familiar with independent validation and verification of requirements and specifications. They have prior knowledge of DSWA radiation test facility developments. Northern NEF is a small disadvantaged business located in Colorado Spring, Colorado. They are experts in training and the production of training material.

H&N provided independent safety hazard analysis and structural reviews. H&N provided building reviews during the design phase. They also provided pertinent information when issues arose that warranted an independent review. Finally, H&N was the design architect for the Safety and Security System and provided oversight during its installation to ensure satisfaction of design requirements. ITT's ability to utilize and provide DSWA the ability to have an independent consultant has saved the program time and money on technical conflicts.

Northern NEF and Metatech played a much smaller role than what was originally expected. As the program evolved and progressed, the requirement for detailed training material was eliminated. As a result, Northern NEF's role diminished. Early in the program, they produced a draft training video. This draft video never was completed due to the change in the program requirements. The remaining training material was handled by internal staff at ITT. Metatech was to provide support in facility integration testing, but the DSWA decisions to delay simulator installation and institute risk reduction research eliminated the requirement for integrated testing.

ITT has established a cohesive and flexible team capable of providing all the necessary expertise to successfully integrate the DECADE facility to meet the requirements and specifications set forth at the onset of the program. Due to the large scale of this program, ITT has organized personnel resources along functional lines with the ultimate responsibility and authority with the Program Manager. The eight major functional areas are configuration management, interface controls, scheduling and resources, data acquisition system, radiation shielding, onsite construction monitoring, system test and evaluation, specification and design maturation. Figure 2-2 shows a top level organizational chart.

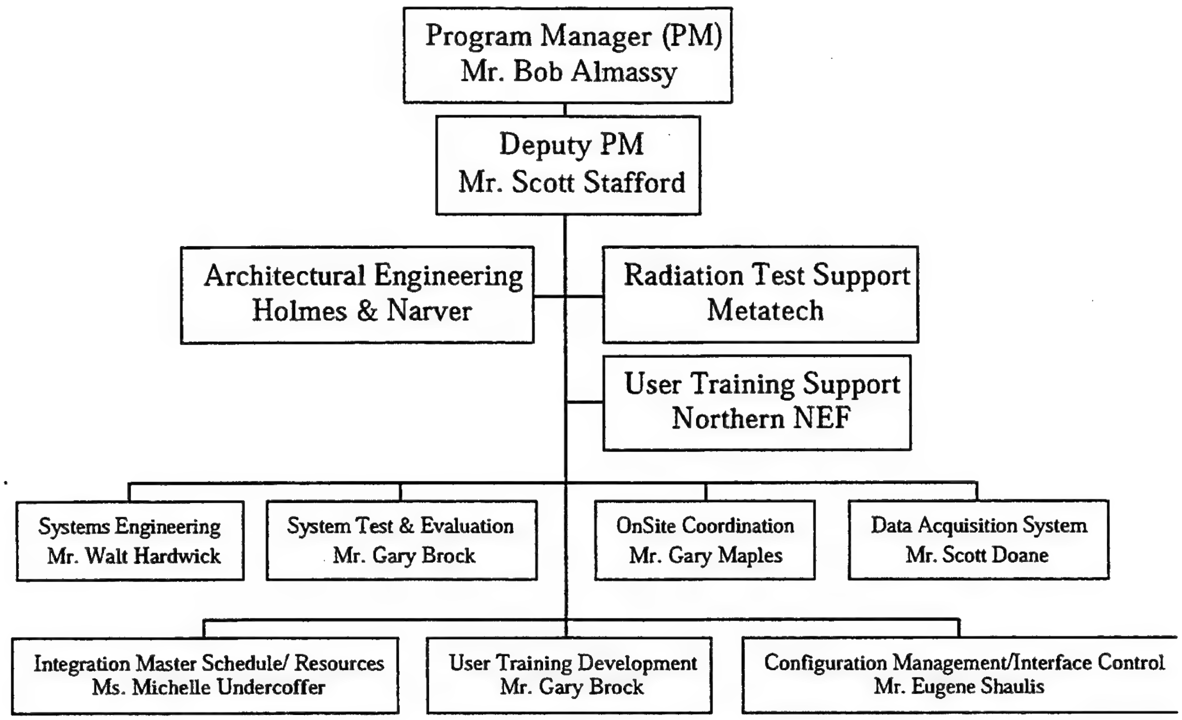



**Figure 2-2. Top Level Organizational Chart**

Over the seven year contract duration, ITT has maintained continuity and flexibility concerning personnel support. There has been no major change in personnel over this time frame. Because of ITT's broad scope of capabilities, we have been able to provide a flexible yet continuous work force. The key personnel have remained dedicated on this program. Yet when specific issues rose which required specialized expertise, we have been able to pull resources from other areas of the corporation to fill that requirement until a resolution was reached. This ability provided a cost effective and technically exceptional support staff.

ITT has had approximately eight personnel located in three different locations working on the DECADE program at any given time. The Program Manager and immediate support staff has been located in our Alexandria, Virginia, office. A ITT field office was established onsite at Arnold Air Force Base at the onset of construction of the main facility. This office was manned by one person who was responsible for construction oversight and monitoring on DSWA's behalf. Personnel at our Colorado Springs, Colorado, office have provided technical oversight of many of the specific engineering efforts.

Due to the diverse location of personnel both on the ITT team and in the program, it was critical to maintain communications with the PMO and other ITT personnel. Until the de-emphasis on building and installation at AEDC in early 1996, the Alexandria personnel participated in a weekly Monday morning staff meeting chaired by the DSWA DECADE

PM. This provided a forum to disseminate information to and from the PMO concerning the overall program. At each meeting, ITT provided a status update on the overall program as well as individual integration problems and issues. A discussion to prioritize the activities for that week allowed the ITT team to focus on critical issues at hand. These activities were very flexible and done impromptu. ITT's participation in the staff meetings provided a way for the PMO to gather accurate up to date information about the overall program. Additionally, ITT participated in a weekly building teleconference to update the on-site building status. Both of these meetings were discontinued as regular events in early calendar year 1996.

ITT had no contractual authority over any other element in the program. We served as an independent assessment team to provide systems integration support to the DECADE facility with the best interest of the DSWA in mind. ITT established a credibility with each of the element contractors as a positive influence and support member. In the best interest of DSWA, ITT provided an independent assessment of conflicts to minimize cost and schedule slips and degradation of technical performance. This role benefited the overall DECADE program by reducing "gold-plating," pointing out design shortfalls, providing cost effective resolutions and minimizing schedule slips. Examples of benefits for DSWA are described in greater detail throughout this report.

# 3. FACILITY INTEGRATION SUPPORT AND SPECIFICATION DEVELOPMENT

## 3.1 SPECIFICATION DEVELOPMENT INTRODUCTION

ITT played a major role in the development of specifications for all DECADE elements (Simulator, Building, User Data Acquisition System, UDAS Shielded Enclosure and Safety and Security System). Our involvement began with requirements definition and continued through construction and installation.

### 3.1.1 Simulator Specifications

#### 3.1.1.1 Simulator Requirements Definition

##### 3.1.1.1.1 Simulator Procurement Support

At the onset of ITT's contract, DSWA was in the midst of two separate Advanced Technology Programs, both research efforts including Maxwell Laboratories, Inc. (MLI) and Primex Physics International (PPI). One of the research programs was for pulsed power improvements and the other addressed primarily plasma opening switch technology. As these efforts reached culmination, DSWA began developing the performance specifications for the DECADE Simulator contract. DSWA and their team of consultants (NSWC, NRL, NSRC, and RDA) developed the majority of the specifications. ITT's role in this effort was to make sure the RFP was complete and clearly written.

After receipt of the proposals and initiation of the source selection process, ITT served in an advisory role to the Source Selection Evaluation Board (SSEB). In addition, we hosted the SSEB and its advisors in our Alexandria facility for the entire evaluation period. Though we provided recommendations covering all aspects of the proposals, our primary focus was on management and O&M issues. One of our key contributions was the establishment of a quantitative scoring methodology. This methodology translated the technical and programmatic assessments of the evaluators into objective measures that could be used to weigh the proposals against the evaluation criteria. ITT retained copies of source selection data until DSWA/AM determined that their records were complete and then retained only technical design data as part of the data depository.

##### 3.1.1.1.2 Radiation Diagnostics

ITT performed a complete review of the PPI radiation diagnostics suite with respect to the requirements of the nuclear weapon effects user community. Subsets of this issue were questions of whether the DSWA Technical Specifications Document (TSD) of the PPI contract satisfies users' radiation diagnostic needs and whether the proposed PPI radiation suite satisfies the TSD.

ITT identified the TSD and the proposed PPI diagnostics to be complete and adequate for a typical AGT user. However, we identified the potential emergence of a new class of

user, one relying (in the absence of UGTs) on the DECADE facility for validating the nuclear hardness and survivability of military hardware. This class of users requires more types of diagnostics that can be reduced and ready for review no later than one hour after the shot. One such class of diagnostics is optical imaging diagnostics, and we judged the TSD document inadequate since it does not require such instruments.

The TSD did require a time resolved spectrum measurement. We found PPI's solution inadequate in this regard and recommended that Berkeley Research Associates' 13 channel time resolved spectrum technique be funded and purchased for DECADE. DSWA funded BRA's time resolved spectra measurement scheme and funded PPI to produce several new radiation diagnostics as a result of our study.

As the program was extended, ITT continued to make DSWA aware of a missing intetrated diagnostics plan. Both DSWA and AEDC are pursuing a variety of diagnostics, but these procurements seem to lack a thorough assessment of user requirements. This should be considered as the facility approaches IOC.

3.1.1.1.3 User Test Chamber.

As a result of ITT's experience as a user at existing Above Ground Test (AGT) facilities, we were able to take a more active role in the requirements definition of the User Test Chamber. As PPI's design progressed, ITT realized that the test chamber specifications included in the original procurement package were inadequate to ensure that a user's needs would be met. We noted, for example, that the specifications included no description of the x-ray exposure window. ITT reviewed these specifications, performed analyses, and surveyed the user community to determine if additional consideration should be given to the capabilities of the vacuum test chamber. Table 3-1 describes these results and recommendations that were submitted to DSWA and PPI in a series of ITT memoranda. DSWA ultimately chose to eliminate the chamber requirement from PPI's quad deployment contract. Our suggestion should serve as a good foundation when a future procurement is initiated.

**Table 3-1. DECADE Test Chamber Design Issues**

| *Requirement* | *Recommendation* |
|---|---|
| Noise Reduction Considerations. | |
| • Keep the radiation-induced drives on these cables below the 10 mV goal in the UDAS Specification. | • 10 cm of lead shielding around cables connecting the users' experiment(s) to the outside of the test chamber |
| • Preclude disruption of test data from RF leakage through planned radiation entrance window. | • Ensure window design provides an RF seal. Recommend RF attenuation goal be the same as the RF shield trough: 74 dB from 1 kHz to 10 GHz for electrical plain wave fields. |
| • Provide experimenters with capability to use test chamber as the outer shield of a Faraday cage or as an extension of the screen room. | • Ensure chamber can be electrically isolated from the test cell platform. |
| Configuration, Mobility And Dose Control. | |
| • Ensure handling safety for chamber with full test configuration weight as high as 5000 kg | • Pneumatic or hydraulic system should be used to position the test chamber. |
| • Allow shielding of jumper cable connections from the vacuum flanges on the chamber to the permanent instrumentation cable plant | • Position vacuum flanges along the sides, bottom and back end of the test chamber to coincide with the placement of the jumper cable shielding stacks. Take advantage of the self shielding provided by the experiment and other objects that may be mounted in the chamber, reducing the amount of lead shielding required. |
| • Support flexible test object positioning in the vacuum chamber. | • Explore potential hanging/mounting system alternatives: sliding rails, moved for each experimenter's particular position requirement; hooks welded to the vacuum chamber wall for each experiment; or a removable hanging steel plate upon which AEDC can weld mounting hooks. |
| Space Environment Simulation | |
| • Support optical experiments with very low infrared light level requirements | • Consider adding specification for cryogenic cooling of the vacuum test chamber or liner, either at IOC or at a later date. |

### 3.1.1.2 Simulator Design Maturation

ITT served a number of roles during the development of the simulator design. Our primary objective was to ensure that the simulator can be integrated with the other elements with minimal problems. Our broad engineering capabilities also allowed us to raise issues about manufacturability and ease of operations, in addition to likelihood of meeting the requirements.

#### 3.1.1.2.1 Simulator Design Reviews

The nature of PPI's design and their requirement for early ordering of long-lead components forced multiple PDRs and CDRs. The first design review occurred in August, 1992, while at the time this report is being written several components have yet

to reach CDR. ITT participated in all simulator design reviews. For each review, we reviewed the submittal packages from several different perspectives. The categories of things we looked at included: external interfaces, operations and maintenance, manufacturability, safety, and the feasibility of the design meeting the performance requirements. We also tried to retain focus on the impact of each system design on system-level requirements. This was complicated by the lack of a single PDR or CDR which addressed the traceability of subsystems downward from the system specifications. As a result, the design reviews were typically focused only on simulator subsystems. For example, ITT made it a point to ensure that PPI re-addressed system reliability, availability and maintainability as more and more data became available.

We typically distributed the package to each of our three DECADE operating locations, so we obtained all of the appropriate review perspectives. As necessary, we held internal teleconferences to discuss major issues and questions. If appropriate, we pointed out our key concerns to DSWA and PPI in advance to allow more effective discussion during the meeting.

During each review meeting, ITT made every effort to keep discussion focused. When it became obvious that an issue went beyond the scope of the meeting, we made sure an Action Item was assigned. ITT documented the actions and made certain they were well understood by the group prior to completion of the review. We incorporated the design review actions into the program-level Action Item database described in Section 4.3.1.1. As responses were submitted, we ensured they were reviewed by the cognizant parties before being officially closed.

The ITT team forced resolution on a number of detailed engineering design issues. Some examples follow:

- During the SF6 System CDR, PPI identified the gas volume upon which their proposed system was based, but were unable to substantiate that design factor. Our insistence on validating that requirement helped to insure the integrity of the design. Based on cost and safety considerations, ITT also championed including a means to shut down the system in the event of a supply line break.
- Another area in which we provided key inputs was the Mobility System. During the Mobility System CDR, we pointed out some incorrect dimensions on the drawings that had gone undetected at PPI. Our questions also caused PPI to perform structural calculations that made sure their design did not overstress the building rails. Fluctuation of the Front End design has resulted in a continuance of this issue, but ITT's emphasis on interface compatibility has ensured that this aspect of the design has become a documented requirement.
- In addition, we pointed out shortcomings in the Output Line retraction/support frame that required an alternative design of the cantilever support arm.

Though PPI's contract required them to prepare minutes for simulator design reviews, DSWA chose rather to have ITT draft them. Because of the importance of these reports

in documenting key design decisions, ITT established a procedure for strict quality assurance and review of draft minutes, which was implemented for every review.

3.1.1.2.2 Ongoing Review Activities

In addition to the formal design reviews, ITT received and evaluated simulator design data on a continual basis. For example, the Auxiliary System design reviews were typically very incomplete. PPI's approach was to define a general design concept. When the community approved the design concept, they would then pursue quotations and design details from the appropriate vendors. As a result of this process, we were forced to review all of the specification iterations that were made available to us. We attempted to ensure that PPI addressed all external interfaces adequately and that they covered O&M and spares. One particular subsystem that PPI and ITT focused on was the Vacuum System, since it had actually proceeded to installation. As the design of this system progressed, ITT worked with PPI and their subcontractor, PSI/CVI, to make sure that interfaces were well understood and operational concerns addressed.

In May 1995, DSWA chose to thoroughly evaluate the switch/load region in an attempt to demonstrate the feasibility of achieving the 20 kRad (Si) specification. In parallel to this Switch Assessment Program, DSWA directed PPI to continue working all incomplete designs. ITT attempted to clarify that direction and assisted PPI in establishing priorities that would support cost effective and expeditious future simulator deployment.

PPI was unable to complete all designs under their original DECADE contract. ITT S&SC played a significant role helping PPI focus on the appropriate activities during the early stages of the follow-on Quad Deployment Contract.

3.1.1.3 Technical Analyses

ITT produced several reports in support of the Technical Advisory Group as they evaluated specific simulator design variants.

3.1.1.3.1 Single Source Radiation Patterns - Gaussian Vs Isotropic

ITT undertook the Single Source Radiation Patterns - Gaussian Vs Isotropic study because we recognized that there were more ramifications than just the granularity of the DECADE ensemble radiation pattern in the exposure plane and the area of 2:1 uniformity. The response of instrumentation cables within the cable plant and how much shielding was required to reduce their SGEMP induced signals to acceptable levels were dependent upon the details of the source attenuation. If the pattern was Gaussian then the amount of cable shielding could be reduced and therefore the already marginal load distribution on the test cell platform could be reduced. If the pattern was isotropic, the uniformity in the exposure plane would be better and the peak dose would be larger.

As a result of ITT's analysis, ITT recommended that future tests include TLD arrays on a spherical surface in front of the machine to determine if the DM1 pattern is isotropic.

PPI reduced the firing jitter on the DM1 test to 8 nsec. Although this was noteworthy, ITT's statistical analysis of the data suggested a high probability that one of the diodes could fire enough in advance, that its radiation could reach a peak and decay to less than half value before another diode fired. The early portion of the rise time of the radiation pulse was critical in determining if this should be of concern to large system testers. For experimenters fielding systems experiments that incorporate circumvention circuits, this situation could represent a significant deviation from an actual weapon environment and be troublesome. If the circumvention level was set for a design margin of ten, it was possible that critical circuits could be exposed to dose rates that would produce upsets before the circumvention circuitry had a chance to trigger. As a result of this temporal analysis, it was recommended that the very early portion of the radiation pulse be carefully characterized.

Our models, provided to both the TAG and PPI further indicated that this anamoly would be especially significant for test items in which the separation of circumvention circuits and other critical circuitry was more than 40 cm in the radiation test plane.

3.1.1.3.2 DECADE 16 Module Randomized Dose And Dose Rate Profiles

ITT conducted this analysis to provide a tool and a visual aid to understand the sensitivities of the DM1 module data (non-zero jitter, varying pulse width, and varying position of the center of radiation) to the radiation pattern and temporal characteristics of the full DECADE ensemble. This tool allowed dose and dose rate maps to be created and gave visual indications of how areas within the exposure plane would be irradiated at specific times during the firing of the complete DECADE ensemble. Data was presented as total dose, dose rate profile maps, and maps of the 2:1 profiles for the specific exposure plane distances.

This analysis reinforced our concerns about anamolies affecting circumvention circuits in large test items and helped focus PPI efforts on radiation control on centering the profile since that parameter appeared to be the most critical to temporal uniformity in the radiation plane.

3.1.1.3.3 Square Geometry Dose Profiles

Since May 1995, DSWA has considered building only one quad for the DECADE program. To support this design variant, ITT studied the two diode placement geometries being considered: the staggered, or hexagonal-close-packed, arrangement and a square geometry.

The preliminary results of this study indicated that the square geometry would provide about a 10% increase in the dose area product within the area of 2:1 dose uniformity, but might produce a slightly lower peak radiation. PPI has since considered canting the diode out of the diode plane, primarily to achieve design simplicity and cost reduction, and the effects of this change on our preliminary results has not been addressed. This issue is still unresolved.

### 3.1.1.4 Coordination/Resolution Of Installation Issues

During the development of the simulator, ITT participated in all reviews with one goal being avoidance of technical issues during planned installation in the DECADE facility. This section describes our interactions with PPI and the rest of the simulator community.

#### 3.1.1.4.1 General Process

The general process for coordinating and providing efficient resolution to installation-related issues revolved around ITT's participation in design reviews and intimate familiarity with building design and construction. ITT established a close, working relationship with PPI engineers in order to provide timely responses to engineering and hardware questions raised during the design and installation phases. PPI relied on ITT's on-site presence for as-built condition updates which saved money by reducing the amount of PPI field engineering.

Additionally, all structural and architectural impacts of simulator design variations were assessed by ITT team member, Holmes and Narver, since Corps of Engineers funding for LAN was no longer available. The net result of ITT's involvement in coordination and timely resolution of installation issues was the absence of work stoppages, major building retrofits, or scope increases to the PPI contract due to building interfaces.

#### 3.1.1.4.2 Simulator Assembly Planning

ITT coordinated simulator assembly plans with PPI, AEDC, and the Corps of Engineers. As the building completion schedule slipped beyond the PPI simulator assembly date, ITT collected details for coordinating joint occupancy issues in the test cell to avoid impacts to PPI and minimize construction interferences to RNJ. A meeting was first held in March, 1994, at AEDC with PPI engineers, AEDC, and Corps of Engineers representatives. Major topics included the assembly schedule, manpower issues, AEDC safety and environmental requirements, and resource requirements. A list of PPI equipment and tool requirements was prepared and negotiations were held with AEDC to determine what resources could be provided by the Air Force to reduce costs to DSWA for assembly. Projected building conditions were factored into the assembly plan with work-arounds established for conflict areas. As schedules became more refined, ITT held a second assembly meeting at PPI in September, 1994, to reassess requirements and define resource needs. Throughout this planning effort, ITT performed the role of unbiased observer to minimize cost growths, maintain overall system requirements, and communicate vital information to affected elements.

##### 3.1.1.4.2.1 Deionized Water Modification

Space allocation studies and interface details were continually updated to reflect the maturation of PPI designs for various systems. An example of a sizable change was the tank area modifications to accommodate the DI water redesign. The DI water system changed from four independent, quad-mounted units to a centrally located single unit.

Impacts to building designs were assessed with the overall goal of minimizing costly changes to ongoing building construction. ITT analyzed the building changes brought about by PPI design modifications and drafted Engineering Change Proposals (ECPs) to minimize construction costs and schedule impacts. The magnitude of the ECPs ranged from walls being deleted to allow efficient delivery and placement of PPI equipment, to analyzing HVAC and power distribution systems. ITT established open communications and a working relationship between RNJ subcontractors to foster the determination of the best method of implementing structural changes to the building without major impacts to the program. These changes were implemented prior to construction so demolition and retrofitting was avoided.

3.1.1.4.2.2 Marx Tanks - TCS - Rail Installation

As a result of ITT's participation in the design reviews for the simulator, several design overload areas in the test cell floor were detected. A study was initiated utilizing ITT's subcontractor, Holmes & Narver, to assess the LAN concrete design and obtain an independent opinion. Results of this study prompted PPI to modify the caster design to redistribute point loads and avoid exceeding the design loads. To assist PPI in planning the test cell travel paths for marx tank placement, ITT confirmed the trench grate load capacity. Field as-builts were then prepared and presented to PPI for assessment of simulator travel limits. Prior to installation, ITT addressed beneficial occupancy issues, crane operations, and RNJ construction schedule modifications to allow clear access to the test cell floor for Comsteel to install rails without interference and cost increases caused by delays. As a result of ITT's coordination, the rail installation was executed without delays and within budget.

3.1.1.4.3 Vacuum System

ITT assisted PPI with a space allocation and systems impact study for the basement vacuum system installation. We prepared a CAD layout of the basement and provided it to PPI for planning and design. We studied building power to determine adequacy for maturing PPI designs. ITT also reviewed PPI's subcontractors statements of work for installation of equipment and power requirements. In addition to the reviews, ITT fielded questions from subcontractors, and provided building tours and photographs to clarify design issues which resulted in cost saving in installation contracts. In order to eliminate construction conflicts, ITT provided the Corps of Engineers and RNJ equipment delivery and installation schedules. When PPI personnel were not on-site, ITT relayed progress and installation issues to PPI engineers.

3.1.2 Building Specifications

3.1.2.1 Requirements Definition

Immediately after award of the SE/IS contract, ITT became involved with defining the building requirements. Prior to that time, DSWA, the Corps of Engineers and the design firm, Lockwood, Andrews and Newnam (LAN) had agreed upon some of the top-level

requirements. However, it was not until mid-April, 1991, that PPI and MLI were brought into the detailed building design discussions. We promptly assumed responsibility for ensuring that building interfaces and operational requirements were defined well enough for LAN to stay on schedule with the design. The fact that the building design led the simulator design by years for some subsystems complicated this effort significantly. This situation resulted from the Congressional schedule for military construction approval. Additionally, this schedule constraint forced DSWA to design two different buildings all the way to the 90% stage. The original plan was to design one building that could house either the MLI or PPI simulator. This was attempted up to the 15% level. At that time, ITT pointed out many of the difficulties this approach would create. DSWA decided to proceed with separate building designs since the two simulator concepts were too dissimilar. As a result, every time there was a design review it was necessary to hold two separate meetings so as not to divulge any competition sensitive data.

With ITT's past Nuclear Weapons Effects (NWE) testing experience we were able to quickly understand all of the support systems required to operate a NWE facility, thus allowing us to ensure these needs were translated into building design requirements. In addition, we had H&N to provide an independent A&E perspective. Because of their inputs, some needed requirements were added to the design and the design package was more complete than it would have been otherwise.

Another benefit that our independent perspective generated was a focus on user-friendliness and reduced operating costs. Whereas AEDC had a similar outlook, we typically played the devil's advocate to ensure that some level of cost benefit analysis was performed and that desired requirements were reasonable. Steam heat, grounding and screen room cooling were some of the requirements that we looked at closely.

In addition to coordinating design requirements with MLI/PPI, AEDC and DSWA, ITT used our expertise to recommend certain building requirements. We queried AGT users, both internal and external to ITT, to determine the type and amount of instrumentation that they typically bring to support x-ray exposure tests. Review of two experiments, PORTS and TRIDENT, showed the screen room floor space to be inadequate to house ground support equipment necessary for operating either of these experiments. As a result of our investigation we recommended that DSWA increase the floor space in the UDAS shielded enclosure from 500 $ft^2$ to 1000 $ft^2$. We also recommended increased power and cooling requirements that were incorporated into the design. Similarly, we gathered data and recommended what services were needed in the support trailer area. Since the Safety and Security System design was going on at the same time as the building design, we were able to ensure consistency between the two.

ITT also forced resolution of the issue of radiation shielding requirements. We evaluated the applicable state and federal regulations and recommended that the guidelines for occupational exposure limits be followed. However, DSWA and AEDC agreed to try to achieve the more conservative exposure limits defined for the general public. ITT ensured the construction impacts were fully understood.

### 3.1.2.2 Building Design Maturation

#### 3.1.2.2.1 Design Reviews

ITT and H&N reviewed the building design at each design stage (15%, 15% re-design, 35%, 60%, 90% and 100%). Our reviews covered all aspects. We made sure that LAN incorporated changes agreed to at the previous stage and that they carried out the design of all external interfaces properly. We also pointed out areas where additional details were required, and we helped reduce confusion during bidding and construction by identifying inconsistencies in the package.

H&N divided the package into disciplines (civil, structural, architectural, mechanical and electrical) and obtained comments from their respective engineers. Each of our internal team members reviewed the design and was given the opportunity to provide written comments. We reviewed all of the comments for consistency and completeness, and then consolidated them, reducing the amount of time required to address them during the review meeting.

Both ITT and H&N attended and played a significant role in the design review meetings. The review process did not allow all organizations' comments to be consolidated prior to the design review meeting. We facilitated this cataloguing process at the beginning of each review meeting. As comments were reviewed during the meetings, ITT helped ensure the resolution was understood and well documented. We recorded Action Items in those situations where LAN required additional data.

#### 3.1.2.2.2 Design Issues

ITT interacted with the COE and its contractors so frequently that we were actively involved in every design consideration and modification. As an example (as mentioned previously), DSWA and AEDC agreed to a very conservative approach to radiation shielding. As a result, ITT made it a point to see that the regulations were interpreted properly and that the design outcome was reasonable. LAN's early design included a three-foot thick Test Cell ceiling, which in theory would have allowed an office to be constructed on the roof. We argued strongly that the requirement is to protect individuals in the offices or work space adjacent to the Test Cell or people that may be outside the building on the facility grounds. We performed the skyshine (radiation backscatter) analysis summarized in Section 4.1.4.1 based on the general public exposure limits. ITT provided our report to LAN and they ultimately modified the design, making the ceiling only nineteen inches thick. This change was never quantified, but the cost savings had to be dramatic.

#### 3.1.2.2.3 Major Redesigns

As the design progressed, there were several instances of major redesign. In general, formal procedures were not followed since the baseline design was not yet established. However, ITT ensured that at least an informal cost benefit analysis was performed prior

to making a major change. Once the community agreed to carry out a change, we led the effort to make sure LAN was given all of the data they needed.

The most significant change carried out prior to release of the design was the "simulator fan-out." In this case, there was a very thorough evaluation of the impacts because of the timing and major ramifications. The configuration control process described in Section 3.2 was adhered to fairly strictly. Upon approval of the simulator design change, ITT took the lead in communicating the new requirements to LAN, who in turn produced three design options. Our inputs helped ensure the reviewers understood the impacts of all three options. The CCB reached a decision and the change was implemented without creating drastic schedule impact.

#### 3.1.2.2.4 Design Shortfalls

When the 100% design was achieved, the community was aware of a substantial number of design shortfalls. Many were minor details or drawing inconsistencies, while others were significant changes that resulted from a developing understanding of the Simulator and User DAS. Because of the schedule constraints it was not possible to revise the drawing package and delay award of the contract. Instead, it was agreed to handle deficiencies after award. ITT established a database to track the resolution of all shortfalls, of which there were 197. Included in the database was a detailed description of the shortfall, the impacts of not resolving the shortfall, whether it was a design deficiency or a user requested change, when it had to be addressed without delaying construction, the priority, possible work-arounds and alternative solutions. We used this management tool for the first nine months of construction to ensure the Corps of Engineers resolved the problems in a timely manner. The Corps of Engineers typically handled the minor details by clarification letters, while the more significant items resulted in the first Engineering Change Proposals.

#### 3.1.2.2.5 Post-Award Design Changes

Since the building design preceded the detailed designs of the Simulator and User DAS, several major changes were proposed after the construction contract was awarded. ITT evaluated each of the proposed changes in detail, gathered information to support the decision process and helped expedite the changes through the control process described in Section 3.2. Once a change was agreed to, we took responsibility for obtaining and communicating all the necessary details. An example of one such change was the addition of the direct penetration of the concrete shield wall between the Test Cell and User DAS Room. This particular item was a design shortfall. ITT and AEDC expected the penetration to be part of the final design, but it was not. We coordinated with AEDC to define the size requirements. During a meeting with LAN, we evaluated specific options for size and construction materials. Once the community agreed to a design, ITT performed the analysis to ensure that the radiation safety hazard could be mitigated. A detailed description can be found in Section 4.1.4. An associated change was to increase from one shielded platform cable trough to three. Finally, when AEDC presented the

User DAS preliminary design, they described some of their anticipated interfaces with the platform; specifically the large, lead-shielded junction boxes to be hung underneath the platform and the shielding material to protect cables all of the way to the test chamber and/or test article. These new design details caused us to reevaluate the load-bearing capability of the platform. We obtained weight data from AEDC and PPI for all equipment they planned to place on or attach to the platform. Additionally, we considered several testing scenarios and generated a reasonable worst case loading scenario. ITT consolidated this information and presented it to LAN. The result of their re-analysis was that two of the beams had to be stronger than required by the original design. Since we had identified a likely change to the platform, the Corps of Engineers had asked RNJ not to order the materials for the platform until the redesign was complete. Thus the cost impact of this portion was minimized.

#### 3.1.2.2.6 Submittal Review

At the onset of construction, the Corps of Engineers and RNJ worked out the submittal register, which was intended to be a record of all the information that RNJ had to provide prior to acceptance of the building. ITT identified the ones we were most interested in reviewing; primarily those addressing interfaces, O&M, safety and training. As RNJ responded to their submittal requirements, we evaluated the data and provided comments to the Corps of Engineers. When the process became bogged down, such as with the overhead cranes, we attempted to force the issue as much as possible. In those cases, we evaluated all comments to make sure they were reasonable and consistent with previous agreement.

#### 3.1.2.2.7 UDAS Power And HVAC Analyses

ITT performed analyses on the AC power and HVAC requirements for the UDAS screen room and found both the AC power and HVAC to be inadequate. We performed analyses of the power required by each type of recorder, timing and triggering circuit, control computer, and typical ground support equipment necessary to conduct large experiments. We performed these analyses for 110 Vac, 208 Vac, and 480 Vac. The transformer supplying power to the screen room was enlarged based on the results of our study.

We also calculated the heat produced by these electrical power requirements, added in heat from lighting and personnel loads, and found the air conditioning capacity was also inadequate. By proper analyses we were able to produce new HVAC requirements into the shielded enclosure design.

### 3.1.2.3 Technical Analyses

ITT has performed several technical analyses on the building design and integration issues. The following section highlights some of the major issues with their outcome.

#### 3.1.2.3.1 Electrical Grounding Systems

ITT performed several independent analyses of the electrical characteristics of the facility grounding systems. We also monitored the construction of the DECADE building to ensure the "as designed" features of the grounding system were correctly implemented. The grounding systems are critical to the safe and low-noise operation of the simulator. Adequate grounding is provided by seven integrated subsystems: two earth ground terminal or counterpoise systems, a lightning protection system, the simulator electrical safety system, the steel rebar in the test cell volume, the radio frequency (RF) screen rooms, and aspects of the alternating current (AC) power distribution system. An early requirement for a cathodic protection system was eliminated during building design. The following Table highlights some of the ITT analyses associated with the grounding systems.

**Table 3-2. Grounding System Analyses**

| *Discussion* | *Analysis* |
|---|---|
| **Earth Terminal** | |
| The two earth terminal systems consist of 23 test wells drilled around the perimeter of the building connected with a single loop of copper wire, ten separate isolated wells located in the test cell area and near the electrical equipment room. These wells are constructed with a four inch diameter hole drilled 40 ft. into the earth. A 3/4 in. Cu rod is placed into the hole and it is back filled with a ground enhancement-material (GEM). | ITT independently calculated the "surge impedance" and the dc resistance for the wells in the earth terminal and verified that, when interconnected, system impedance will be about one ohm at low frequencies and less than 15 ohms at high frequencies. |
| **Lightning Protection** | |
| The Lightning Protection System consists primarily of air terminals located on the roof parapet and distributed over the roof near other structures. The terminals extend to a height exceeding the other structures on the roof. | ITT reviewed the layout of the air terminals, and recommended changes to the placements of these air terminals to provide better protection of the instrumentation and machinery located on the roof. |
| **Machine Electrical Safety** | |
| Electrical safety of high voltage equipment like the simulator is a primary concern. Thirteen pads in the test cell floor provide electrical grounding connecting points for the simulator. These pads are tied into the rebar and the earth terminal counterpoise system. | ITT reviewed the design and operational requirements concerned with machine electrical safety with the main focus on personnel safety. We determined that routine simulator maintenance requires the aft section of the Quads be moved and this will require that the straps connecting the simulator to the grounding pads be disconnected and reconnected each time. We recommended that full documentation of required operational safety procedures be added into the maintenance procedures manual. |
| **Rebar In Test Cell** | |
| The steel structural reinforcement (rebar) in the test cell floor, walls, and ceiling enhances the electrical conductivity of the structure and prevents RF leakage from the test cell. By helping to contain the electrical energy within the test cell, however, the shielding effectiveness of the structure can add to the noise ("ring-down" ) detected by the test instruments. | ITT reviewed the construction techniques for installing and interconnecting the rebar in the test cell. We calculated the engineering trade-offs between shielding effectiveness and "ring-down" and recommended designs to optimize rebar interconnection. Our report also recommended techniques to shield the electrical systems outside of the test cell to mitigate problems due to electrical energy leakage during testing. |

#### 3.1.2.3.2 UDAS Shielded Enclosure

Studies were performed by ITT to determine the worst case screen room shielding scenario as a result of firing DECADE with the user vacuum chamber isolated from building grounds. In addition to this study, calculations were also performed to determine the steel wall thickness needed to provide 120 dB shielding effectiveness. The calculations showed a 1/4 inch thickness would meet the specifications. The walls, ceilings, and floor of the Shielded Enclosure were fabricated with 1/4 inch steel sheets with seam welds. Construction consisted of a "single walled" enclosure rather than "double walled"

construction. The spark gap break-over voltage requirement was another specification recommended as a result of these studies.

3.1.2.3.3 EMP Study

ITT conducted the electromagnetic pulse (EMP) study to develop a model for prediction of the EMP fields generated within the DECADE test cell which could also be conducted outside the test cell. We used the PRES code to determine the time dependent EMP environment generated inside the test cell. Then those EMP waveforms were used as input to a separate model which predicted the attenuation of the fields through the test cell walls. This information was needed for calculating the effects of the EMP fields on instrumentation, communication networks, the grounding and shielding inside and outside the test cell, and the effects on the utility power and instruments powered by those circuits, such as the overhead crane.

Results indicated the EM energy radiated upward through the test cell roof was in the order of 1.7 watts/m$^2$ and should not present a problem for other electronics located at AEDC or affect aircraft flying overhead. Immediately outside of the west wall of the test cell, we predicted the magnitude of the EM field would require that cable routed in this vicinity be protected by EM shielding. We recommended that unprotected wires running through this area, such as twisted pair, utility power, and communication wires, be run inside metal conduit. Coaxial and TSP wires do not require any further shielding to prevent burnout and upsets within electrical equipment.

3.1.2.4 Coordination/Resolution Of Construction Issues

3.1.2.4.1 General Process

The process of continually refining the building design during construction involved ITT's participation in all element design reviews and intimate on-site monitoring of RNJ progress. ITT maintained on-site presence from September, 1993, through September, 1996, and established open lines of communication with AEDC, Corps of Engineers, and RNJ and their subcontractors. ECPs were prepared after thorough examination of the impacts to the RNJ contract. Contractors were consulted to determine the most effective and efficient method of implementing construction changes. ITT worked closely with AEDC to monitor the RNJ construction effort and provided continuity in design understanding. The net result of this effort was the timely, cost effective resolution of midstream construction changes that enhanced overall system performance without disrupting on-going construction and incur major cost increases.

3.1.2.4.2 Planning Meetings

ITT participated in both the weekly Corps of Engineers/RNJ and AEDC staff meetings. The RNJ meeting was combined with the AEDC meeting and became the weekly integration meeting as the RNJ construction work tapered off. Installation issues that affected schedule, manpower, and resources were presented and resolved to minimize

conflict between elements. In addition to the weekly meetings, ITT called many meetings to resolve specific design and construction issues to clarify missing interfaces and problems. Some of these topics include HVPS safety decisions, telephone design and installation, UDCN cabling design, and Corps of Engineers/RNJ subcontractor meetings.

#### 3.1.2.4.3 Changes, Resolved Problems, Issues

ITT assumed the responsibility of writing the majority of the building ECPs. The building construction contract brought about many minor and significant changes as a result of maturing element designs. The change proposals were studied and determined necessary if they reduced the cost of element installation and only if RNJ construction was not adversely affected. The following paragraphs present examples of the issues addressed and resolved by ITT personnel supporting the engineering change process.

- One of the first procedural changes prompted by ITT was the elimination of work performed on verbal request without Corps of Engineers approval. Many misinterpretations of change orders prompted construction without DSWA review and resulted in cost increases. An example was the RNJ decision, prompted by an AEDC technical suggestion, to weld every rebar crossover because this was a requirement for electrical grounding. This was requiring extra welders on the site and was impacting construction schedules. ITT clarified the requirement and caused this problem to disappear, but only after an unnecessary expenditure of about $200,000. We alleviated the procedural problem by enforcing configuration control procedures for all subsequent changes.
- While reviewing DECADE plans, AEDC engineers and safety personnel classified the HVPS as a transformer requiring that a safety vault be installed around the HVPS. ITT identified this as a local "judgment call" with significant potential cost and schedule impact on building construction. ITT negotiated building changes achieving a reduction in scope from the original AEDC proposed changes. This change was implemented within the RNJ schedule which avoided demolition of existing concrete and reduced the cost of the construction.
- Many of the building interfaces to the elements to be installed were necessarily vague since the elements were still being designed as the building was being constructed. ITT worked many issues that involved clarifying interface designs to decrease eventual costs of installation. An example of this type of issue was the design of the electrical feed-through panel in the simulator Control Room. ITT realized the inadequacies of the LAN design and met with PPI engineers to develop a better concept. This concept was then discussed with RNJ subcontractors to develop a convenient, cost effective, RF tight, cable feed-through assembly that would meet all future needs of the DECADE Control Room. This assembly was produced with minimal design cost and minimal impact to the RNJ construction schedule and avoided additional costs for substantial retrofitting of the Control Room to accommodate system cable installation in the future.

- Studies of the shielding requirements supporting test chamber design predicted a significant increase in the weight of items on the test platform. ITT performed analyses of the platform loading factors and recommended changes to the construction. We brokered meetings with AEDC and LAN on relatively short notice to allow implementation of the changes prior to steel fabrication. We also prompted UDAS engineers to refine their interfaces for cable tray attachments and cabling design. By collecting this vital data quickly and incorporating it in a timely change request, ITT was able to avoid the potential costs of future redesign and replacement of the test platform.
- The shielded enclosure design required concrete modifications that were designed only days before excavation and placement of building concrete was to take place. ITT worked with NISE East/MMM Design Group, AEDC, Corps of Engineers, and RNJ to implement a change on very short notice and yet not bypass configuration control procedures. The execution of this change and the cooperation of all elements involved was only possible due to the partnering concepts employed by the Corps of Engineers and nurtured by the ITT on-site engineer. Though a small slab of concrete had to be removed at a later date, the cost savings was substantial compared to the excavation and replacement of concrete that would have been required to accommodate shielded enclosure design.
- After the test cell concrete had been poured, ITT discovered that the conduit for Safety and Security System (SSS) power supplies had been omitted inadvertently. ITT worked on the SSS design with NISE East and RNJ/Harlan to minimize retrofitting the building while still obtaining the needed interfaces without incurring cost increases to the SSS installation. The results of these efforts was the reduced cost of RNJ installation and no scope increase to the SSS installation.

Several key changes arose during the last few months that RNJ was on the job when only limited contingency funds remained for ECPs. ITT helped evaluate the changes, identified options and recommended priorities to the Corps and DSWA. Once a modification was agreed to, ITT helped provide the necessary data to RNJ or their subcontractor/s to assure timely execution and minimal cost impact. After RNJ defaulted on their contracts, AEDC continued to maintain a list of proposed building changes that they intended to fund with their operations and/or Site Support budget. We worked with AEDC to ensure the necessity of all changes and we continually advocated the most cost effective solutions.

#### 3.1.2.4.4 Provided On-Site Verification For PMO

ITT provided an independent on-site inspection and monitoring of the building construction for the PMO. ITT verified several vital, system-related areas to assure the PMO of construction adequacy. The On-site Building Verification Requirements (OBVR) process was developed with inspection shared between ITT and AEDC. This effort is discussed in detail in Section 5.1 of this report.

#### 3.1.2.4.5 Provided Weekly Updates

A weekly summary of construction progress and ongoing issues was prepared and distributed to ITT team members via Email by the ITT on-site representative. This was not the only communication that took place between team members, but rather a synopsis of key events submitted for review and comment. Each team member reviewed the issues in his area of expertise and conducted detailed analyses for a final resolution.

This report was typically distributed on Friday afternoons which provided ITT Alexandria up-to-date construction progress information for the weekly DSWA staff meeting.

#### 3.1.2.4.6 Provided Weekly Integration Issues Log

The weekly integration issues log was a tool developed by ITT on-site to track resolution and criticality of short term issues that would have an immediate impact on elements in the field. This log was distributed by ITT during the Monday on-site integration meeting. These issues would prompt responses from DECADE elements for answers to scheduling, construction, or material concerns to avoid impacts and interference with other elements. The log also incorporated input from ITT's two week rolling wave analysis which kept RNJ informed of element activities planned within the building. The tool proved useful in tracking many small items before they created major, costly impacts.

### 3.1.3 Shielded Enclosure Specifications

During the early stages of the building design, ITT recommended having the ability to isolate the User DAS Room from the building. The building design included this capability through the 60% stage. As the design progressed and the difficulties this created became better understood, DSWA decided to eliminate this requirement. Shortly after the PMO was assigned to the DSWA Test Directorate, DSWA decided to reconsider its decision with respect to isolation of the User DAS Room, as well as to consider adding ground rods that could be used to isolate the simulator. Several meetings took place, with ITT being a key participant, and DSWA ultimately chose to pursue this isolation issue further.

Prior to DSWA making a decision on the User DAS Room, we helped make sure they were aware of all impacts. Funding was the obvious concern. Construction had been underway for about six months and carrying out this change under the RNJ contract was considered impossible because of the limited contingency funds. As a result, DSWA was forced to consider other procurement options. Other factors that we raised included schedule delay and the creation of numerous interfaces.

Ultimately, DSWA chose to carry out the change by separating the Shielded Encosure procurement from the building procurement, and they were successful in finding a contracting agent, NISE East. Once those decisions were made, ITT effectively took the lead in managing many aspects of this work, from defining requirements to resolving

installation issues and following through with acceptance. Throughout the entire Shielded Enclosure project, we did everything within our means to expedite completion. Though this may not be apparent from the final end date, we are confident that without our inputs the outcome would have been much worse.

3.1.3.1 Shielded Enclosure Requirements Definition

The electrical isolation requirement had a dramatic effect on the design of the room, thus making it necessary to contract out both the design and installation. DSWA's agreement with NISE East covered both. Prior to initiating the design, DSWA had to define the requirements, which they tasked AEDC and ITT to do. The first step was to determine what needed to be removed from the RNJ contract. ITT worked with H&N to provide an itemized list of changes, in addition to a rough estimate of the cost savings. We provided this list to the Corps of Engineers and AEDC. The Corps of Engineers used it as the ECP for deleting the work from the RNJ contract, while AEDC used the information to form the basis for the Shielded Enclosure design criteria package.

DSWA requested AEDC take the lead with preparing the design criteria since they were most knowledgeable about the User DAS interface requirements. The final package was more complete and easier to understand as a result of our inputs. There were numerous iterations of this document. ITT persuaded AEDC to use and reference the LAN design as much as possible, rather than going back to square one. Also, for those areas where it was inappropriate to refer to the LAN design, we advocated defining true requirements, not design details. Our philosophy was that DSWA was hiring the expertise to work out those design details.

Our previous work defining cooling and power requirements for the User DAS Room , see Section 3.1.2.2, carried over to the Shielded Enclosure design criteria. Our recommendations were to have two transformers serving this room, a 30 kVA transformer for utilities and 112.5 kVA unit for instrumentation. The rationale being that signal-to-noise levels would be higher. The increase in available power also led us to recommend an increase in cooling capacity of the HVAC system servicing the room. We suggested increasing from the original design of 200,000 BTU/hr to 300,000 BTU/hr. However, AEDC and DSWA took this one step further and were advocating a completely redundant system with this cooling capacity. We agreed with the reliability concern, however, our approach was to provide a reduced cooling capacity if one of the computer room units went down. The end system has two units each capable of providing a cooling capacity of 180,000 BTU/hr. If one fails, there will still be sufficient capacity to continue running the majority of instrumentation using the redundant cooling capabilities.

Finally, AEDC completed the design criteria and DSWA worked out all of the arrangements with NISE East. A kick-off meeting was held with NISE East's design firm, MMM Design Group. We essentially led this meeting, making sure that MMM Design Group had a clear understanding of the design requirements and the interfaces their design would have with the existing building.

### 3.1.3.2 Shielded Enclosure Design Maturation

#### 3.1.3.2.1 Design Reviews

MMM Design Group took approximately seven months to complete the design. There were two design review meetings; at the 35% and 90% stages. Prior to each review meeting, ITT evaluated the design drawings and compiled a detailed set of comments covering all aspects of the design. Because of our large role in the development of requirements, we readily pointed out design shortcomings, in addition to ways to make the package easier to bid. We reviewed all of our comments for consistency and completeness, and provided a consolidated list to NISE East before the review meeting.

ITT attended both of the design review meetings and essentially directed the discussion. We made sure all comments were addressed and well understood. ITT ensured discussion stayed focused and if additional information was required, an Action Item was assigned. Subsequent to the meetings we prepared and distributed a detailed report summarizing the key decisions and issues to ensure that everyone had the same understanding.

It was during this time frame that the PMO personnel were being reassigned and DSWA was unable to attend all of the Shielded Enclosure meetings. DSWA requested ITT represent them in those instances. We did this, ensuring the appropriate level of detail was provided to the PM.

#### 3.1.3.2.2 Design Shortfalls

Much like the building design, there were a number of design shortfalls with the 100% design. Again, with the schedule driven project, they could not be resolved prior to requesting bids. AEDC and ITT independently prepared a list of shortfalls. We initiated multiple discussions with AEDC and reached a meeting of minds with respect to a consolidated list. As the procurement process got underway, NISE East addressed some of the shortfalls via contract amendment. The others formed the basis of discussion for the contract award kickoff meeting. Coming out of that meeting, agreements were reached to some increases and decreases in scope. Because of NISE East's restricted contracting authority, our knowledge of the changes was essential. ITT followed them through to construction to make sure they were implemented properly. In addition we helped diffuse Lindgren's argument that the changes warranted an increase in their costs.

#### 3.1.3.2.3 Procurement Process

ITT played a key role in the evaluation of the two proposals. We thoroughly reviewed both proposals and provided detailed comments. We also reviewed inputs from AEDC and NISE East to make sure all comments were appropriate. NISE East relied on ITT to advise them on all issues associated with the evaluations. Where the two bidders raised issues with the design, we helped NISE East understand them and provide clarification. ITT helped with preparing new specifications requiring testing of the filters over prescribed frequency ranges to a 100 dB level and then performing analysis to show that

the filter would meet the 120 dB specification over the required frequency range. In addition we made sure the significant issues were highlighted, so the process was not muddied by minor details.

Once the contract was awarded to Lindgren (LMD), ITT supported NISE East in reviewing the construction techniques, materials, testing and schedule proposed by Lindgren for their adequacy in meeting the specifications of the RFP. We traveled to Lindgren's California office for the kickoff meeting. As mentioned above, we reviewed the design shortfalls list item by item. In addition we helped LMD understand how they fit into the overall project. Again, we fully documented all details of the discussion.

3.1.3.2.4 Shop Drawing Preparation/Submittal Process

Per the specifications, Lindgren was expected to prepare all of the necessary submittals during the first month after contract award. The submittal process quickly broke down so ITT made every effort to ensure that Lindgren prepared critical documentation and obtained approval prior to the particular component being installed. ITT took the initiative to develop a tool to track the receipt and approval of all of the submittals. In the absence of any other tool, this soon became the "official" list. The table contained a brief summary of all submittal comments, including ITT's, AEDC's and MMM Design Group's. It also identified specific items requiring action.

3.1.3.3 Coordination/Resolution Of Installation Issues

3.1.3.3.1 General Process

The general process that ITT followed for the installation of the Shielded Enclosure was the same as for other DECADE elements and involved the ITT on-site engineer participating in the design review process. Key building interfaces were studied during this design phase to avoid costly retrofitting during shielded enclosure fabrication. The building design was changed to accommodate maturing NISE East designs, as long as cost increases and schedule delays were not incurred for the building contractor. The result was a shielded enclosure design with well-defined building interfaces fabricated with no major construction problems.

ITT maintained up-to-date information status for all the issues surrounding the shielded enclosure fabrication. Information was disseminated from the NISE East to other ITT team members to assist in problem resolution. The ability to maintain intimate familiarity with the construction effort and having access to the knowledge and experience of the entire ITT team attributed to a very successful integration of a complex structure into the DECADE building.

3.1.3.3.2 Planning Meetings

ITT requested LMD participate in the weekly integration meetings. LMD briefed the projected work to be completed during the coming week and became familiar with the

other element's work plans for the facility. These weekly meetings provided the opportunity to work any conflicts or interferences before costly delays or shutdowns occurred. ITT also assisted LMD in resolving any issues that arose during the week requiring action prior to the next integration meeting. ITT inspected construction progress daily and provided input for solving many of the small day-to-day issues that affected installation.

3.1.3.3.3 Changes, Resolved Problems, Issues

For several reasons, the installation of the shielded enclosure was removed from the construction program and completed as an equipment installation. ITT wrote the ECP providing the detailed deletions from the RNJ drawing package required by this change. The Corps of Engineers was able to use this detailed description to accurately negotiate a credit settlement with RNJ. NISE East Norfolk took the acquisition responsibility for the shielded enclosure.

The early changes in the shielded enclosure procurement involved additional structural changes to the building. Maturing designs revealed the original RNJ concrete floor design to be too shallow to house the enclosure and still maintain consistent finished floor elevations with the rest of the office area. ITT was instrumental in writing the ECP to modify the concrete design based on MMM Design Group recommendations. This change reduced the cost of the enclosure fabrication by minimizing the amount of concrete work which needed to be performed by LMD.

Once the final weight of the enclosure was known, ITT realized the concrete over the basement might be overloaded. H&N was brought in to inspect the existing conditions before the shielded enclosure was started. Based on H&N recommendations, an ECP was written to install a steel support beam under one area of the enclosure concrete floor for extra support. This minor construction helped avoid a potentially expensive repair.

Beneficial occupancy for shielded enclosure installation by LMD was complicated by the slip in RNJ building completion. ITT participated in meetings with the Corps of Engineers and RNJ to resolve resulting issues. ITT conducted site tours for LMD field representatives and oversaw the cleanup requested by the field representatives prior to mobilization. Laydown areas for LMD materials were reserved and delivery schedules published to keep RNJ informed of planned activities. ITT's work on-site prior to LMD mobilization allowed fabrication work to begin smoothly without delay or interference with RNJ.

ITT review of LMD design submittals was difficult since only very limited information was submitted in a timely manner. In many cases, submittals were received at the same time hardware was being installed. Within the constraints created by this situation, ITT provided review comments to NISE East. Work-arounds and specification changes were reviewed to assure the original design criteria for the shielded enclosure were not compromised and installation was not adversely impacted. Due to ITT's working relationship with the subcontractors on the building contract, many questions were

resolved and design intent clarified allowing the subcontractors to complete subsystem installation. As an example, the requirement that no copper wires pass through the shielded enclosure boundary caused many design difficulties for vendors wanting to supply off-the-shelf (OTS) hardware. ITT met with LMD vendors and recommended work-arounds and approved design changes that allowed the use of existing hardware compatible with OTS equipment, thus reducing the time and cost of designing prototype systems.

The walls surrounding the shielded enclosure were originally deleted from the RNJ contract, to be included with the equipment installation by LMD. A subsequent legal determination by NISE East required that they be added back into the RNJ construction contract. No design was supplied to RNJ detailing the new wall requirements. ITT was influential in providing the necessary design criteria to RNJ to get fire dampers, access panels, door modifications, and card access conduit in the proper locations. Construction was monitored daily to assure electrical standoff distances were maintained. Ducting and lighting interferences were resolved with field work-arounds that minimized construction delays.

Finally, acceptance testing of the shielded enclosure was adversely impacted by Lindgren's under-estimating the effort, time, and cost of having their subcontractor perform the testing. Early in the RF and magnetic testing it became apparent that the subcontractor was not going to meet the tight schedule required by the contract. ITT worked with the subcontractor through NISE East and AEDC to streamline their testing plan so that the testing could be completed, have minimal impact on the completion date of the shielded enclosure, and still assure the shielded enclosure would meet specifications with a high degree of confidence.

### 3.1.4 Data Acquisition System Specifications

#### 3.1.4.1 Data Acquisition System Requirements Definition

ITT played the lead role in defining the performance specifications and requirements for the UDAS. We fulfilled the lead role by issuing the user questionnaire to the nuclear weapon effects community and publishing an analysis of results, chairing the UDAS Steering Group for DSWA, and authoring "Performance Requirements of the DECADE User Data Acquisition System."

This was a critical responsibility because of the importance of the UDAS in the function of the DECADE facility. The quality of the test data is one of the most important aspects of user satisfaction. Defining and documenting the UDAS performance requirements and specifications was a key step to ensure the resources allocated for the UDAS task were expended wisely. Without inputs from the user community and a clear statement of requirements, it would be impossible to budget tasks, select proper equipment, or design a cohesively functioning system.

ITT's performance requirements document added value by giving detailed, specific requirements defining or describing:

- purpose of the UDAS
- physical description of the UDAS
- overall system performance for 5 recorder bandwidths
- through-put requirements
- criteria and capabilities for digitizers
- criteria for trigger and timing equipment
- criteria for cable plant, calibration equipment, and the signal conditioning equipment
- building interface requirements
- staffing requirements

#### 3.1.4.2 Data Acquisition System Design Maturation

As soon as DSWA established the UDAS acquisition strategy, ITT began working with AEDC and SNL to evaluate options for achieving the necessary performance. Because of ITT's experience in fielding instrumentation at UGTs and other types of tests, we were able to bring many applicable lessons learned to the project. In response to DSWA's request, ITT became the focal point on user requirement issues – a natural follow-on from our earlier roles in developing the user requirements questionnaire and authoring the UDAS requirements document.

We played two primary roles during the maturation of the UDAS design. In our technical role, we participated in all of the design reviews and conducted technical and tradeoff analyses that resulted in important design recommendations. In an equally important secondary role, ITT provided unbiased management oversight, as there were several instances where our independent perspective permitted us to recommend improvements in communications or planning.

All formal design review materials we received were distributed among our team and were critiqued for both technical and programmatic content. Our purpose was to evaluate how each aspect of the design would impact the risks to performance, schedule and cost. We reported perceived weaknesses, shortfalls, and strengths, and provided where needed specific recommendations for improvement. We compiled our comments and forwarded them to AEDC prior to the meetings. During the meetings we led discussions on many topics that often prompted detailed side meetings and follow-on conversations. Additionally, we ensured that all action items were acknowledged and documented.

Although AEDC accused ITT of hampering progress because of our oversight-type requests, we viewed our questions as being proactive. For example, DSWA asked us to evaluate the preliminary software design. We assigned this short duration task to one of our Software Engineers in Colorado Springs. He had many constructive criticisms of AEDC's development process that were fed back to DSWA. As a result, we kept a very

close watch over their progress throughout the entire development cycle. Several of our recommendations contributed to the overall success of the UDAS project.

Some of the UDAS design studies that ITT played an active role with include: cable routing options, cable radiation environment, custom versus OTS software, digitizer bandwidth requirements, FCDSWA digitizer capabilities, and detailed interface definitions. The following sections give an overview of several of these activities.

#### 3.1.4.2.1 Cable Plant Issues

ITT played a major role in defining the DECADE cable plant. Our contributions and recommendations were crucial to the selection of cables used in the UDAS, and in choosing their path through the facility. Both of these decisions greatly effect the ability of the cables to deliver low noise data signals to the recording system. To achieve low noise data we had to perform studies on the following topics:

- test platform to screen room cable paths
- radiation response and shielding effectiveness response values of four cables
- radiation effects on four cables, for jumper cables on the test cell platform and for both side and center trough cables running to the screen room
- EMP shielding effectiveness of four cable types
- radiation transport calculations Pb shielding required to produce acceptable radiation induced noise levels
- cable attenuation and insertion loss

Based on the above studies, ITT calculated the noise induced on the cable plant during discharge of the simulator. The calculations were crucial (1) for selection and purchase of cable and (2) for determining the noise floor requirement established for the UDAS. ITT recommended Cujac RG-401 and Cujac RG-402, and these cables were selected for the jumper and test cell cable plant. Knowing the noise floor allowed system designers to determine signal conditioning and digitizer specifications required to meet the system signal-to-noise ratio; thus, our noise floor calculations were crucial to selection of the main pieces of UDAS equipment.

### 3.1.4.3 Technical Analyses

#### 3.1.4.3.1 Cable Trough Shielding Analysis

To aid in the design of the UDAS, ITT conducted a study to determine the radiation induced signal on the center conductor of a variety of cable types that were under consideration for use in the UDAS cable plant. The instrumentation cables, connecting the experiment area and the UDAS, are buried in the user radiation shield trough that runs

underneath the test cell platform. The methodology used for these calculations was to first develop analytic functions, based upon the PPI DM1 test data, to predict the radiation environments at the top and on the inside of the radiation shield troughs. Once the dose rate inside the cable trough was determined, we folded the cable response functions, obtained from published literature, into the calculations.

ITT developed a model for calculating the dose rate inside the troughs, which incorporated the individual attenuation functions of the various materials within the radiation shield trough. We developed the attenuation coefficients as a function of material thickness with independent CEPX/ONELD calculations. The analytic functions were then used to predict the dose rates inside the troughs.

ITT calculated an absolute maximum voltage signal out of the cables by multiplying the average dose rate received along the cable by the termination impedance (50 ohms), the appropriate cable response function, and the length of the cable. The results of this calculation were for RG141 was 0.33 mV, for RG 214 was 8.221 mV, and for foam-filled cable was 65.8 mV. Based on data for a "compensated" system with 50ft. of RG214 cable and a bandwidth of 400 MHz, and 1.94 mV for the resolution of the LSB digitizer, only the RG 141 Cujac type cables meets this criteria.

ITT also investigated the behavior of the cable response as a function of position along the cable length. We determined that the most significant signal was generated in the first 400 cm of the cable trough. Calculations were made with an extra 5.5 cm. of lead along this first 400 cm. for the three cable types.

Jumper cables used to connect the item under test are usually 6 to 10 feet long, and the full length could be irradiated at the maximum output level of DECADE [20 krad (Si) for the 1.5 MeV diode spectrum]. If these cables are Cujac type, RG141, the resulting voltage in 50 ohms is 7.6 V. Based on these values, ITT recommended shielding the jumper cables with lead. Then cable radiation response calculations were made as a function of lead shielding thickness. It was determined that 4 cm. of lead would be required to reduce the induced cable signals to less than 5 mV to meet the criteria.

As a result of ITT recommendations based on these studies, foam-filled dielectric cables will not be used in the radiation shield trough in order to reduce the radiation induced noise to acceptable levels. This work was critical to the definition of cabling and planned shielding procedures for UDAS.

#### 3.1.4.4 Coordination/Resolution Of Installation Issues

The UDAS installation at the DECADE facility was accomplished by the AEDC/Sverdrup development team. ITT assisted in coordination with the building contractor and subcontractors, the SSS installation team, and the shielded enclosure installation team. We also provided independent recommendations that resulted in issue avoidance and resolution. In addition, ITT helped obtain support and approval from AEDC base offices and from the COE. This section describes some of those interactions.

3.1.4.4.1 General Process

The general process for UDAS installation issue resolution involved ITT's assessment and awareness of the DECADE system requirements to recommend effective workarounds that minimized impacts to other elements.

3.1.4.4.2 Changes, Resolved Problems, Issues

Clarification of the cabling interfaces for the three RF enclosures required coordination between the UDAS team and other DECADE element teams, including the base support team. The number of fiber optic and signal cables required for the UDAS systems was not specified in the preliminary design which was guiding shielded enclosure installation. The ITT on-site representative held meetings with the various AEDC agencies to initiate the design efforts to clarify design criteria for the shielded enclosure, control room, and "Baby" SCIF. Estimated system requirements were compiled and provided to the NISE East architects for the shielded enclosure. During the final stages of shielded enclosure fabrication, ITT again prompted design clarification of the UDAS cabling system which resulted in changes to the enclosure design. The changes, involving additions of fiber optic waveguide assemblies and repositioning of the assemblies on the shielded enclosure walls, prevented a costly retrofit during UDAS installation. Retrofits would have required additional welding that might have impacted the stringent RF attenuation performance required.

UDAS installation was delayed due to late completion of the shielded enclosure by LMD and RNJ. ITT assisted with the resolution of beneficial occupancy issues, allowing the UDAS team to move recording hardware into the building early. ITT held weekly planning meetings and daily on-site inspections to monitor progress and assist with the resolution of any installation problems.

3.1.4.4.2.1 Quantitative Risk Assessment of UDAS Software

ITT completed a Quantitative Risk Assessment of the UDAS Software Task for DSWA. The purpose of the risk assessment was to identify critical issues that affect the performance, cost, and schedule of this task. The software task was critical to the UDAS performance and, therefore, to the DECADE project. Software, in general, has a checkered past, and its checkered past raises concern among DSWA managers about the ability to complete the UDAS software task on schedule and under budget.

At the recommendation of DSWA, ITT employed the QRA approach described in Air Force Materiel Command Pamphlet 63-101, dated 15 September 1993. The Air Force methodology decomposes risk assessment into analyses of risk probability factors and risk consequence factors. Using this methodology, a risk analyst assesses the probability of an adverse event occurring in each of the six factor shown in the following table.

The analyst then multiplies these probabilities by risk consequence factors as identified:

- performance
- schedule
- cost

We summed these products to develop an overall quantitative risk assessment score. This approach attempts to address each of the six elements equally, mitigating the subjectivity associated with many risk assessments. This QRA is discussed in further detail in Section 4.1.9.

Our mapping of the six areas referenced in the Air Force pamphlet to the software task was as follows:

| Air Force Risk Probability Factors | Our Interpretation of Risk Factors as Applied to UDAS Software |
|---|---|
| requirements | do we know what we need |
| technology | do software tools exist |
| management | (self explanatory) |
| engineering | this is the software design |
| manufacturing | coding the software design |
| support | resources, spares, maintenance |

Our quantitative risk assessment produced a score of 19 for AEDC and 36 for SNL, indicating medium risk for completion of AEDC UDAS software tasks and significantly higher risk for SNL. To mitigate these risks, we provided several procedural recommendations to AEDC and DSWA.

We found the biggest risk to the project was a poorly functioning interface between SNL and AEDC. We recommended this problem not be underestimated as we believed it would affect future coding, module testing, and integrated system tests between the two groups. The AEDC UDAS team responded to ITT concerns and instituted regular weekly technical interchange meetings via telephone between AEDC and SNL. ITT participated in those meetings. Acceptance of ITT recommendations resulted in significantly improved results on UDAS software, although several schedule slips still resulted from fragmented software development responsibilities.

### 3.1.5 Safety And Security System Specifications

The task of developing the design specifications for access control to and within the DECADE facility was given exclusively to the ITT support team, with much of the technical specification performed by H&N. This role transitioned naturally into oversight and quality monitoring of the subsequent installation by NISE East and its supporting contractors. This section describes those functions.

#### 3.1.5.1 Requirements Definition

ITT and its subcontractor, H&N, had an active role in the development of requirements for a Safety and Security System (SSS) for the DECADE facility. From the beginning, in keeping with the desire to make the DECADE facility a state-of-the-art test site, DSWA and AEDC clearly stated their desire for an automated system. ITT, H&N, and AEDC then worked very closely together to determine the specific requirements needed to define and develop a system specification to protect the safety of people and equipment at the facility and to ensure proper safeguards for sensitive information. This was accomplished through a series of meetings where qualitative and quantitative customer expectations were generated. ITT and H&N used their expertise gained from experience in operations in a radiation test environment, and from developing similar systems in the past, to contribute to the generation of these expectations. ITT also worked with PPI to gain a better understanding of simulator operational scenarios, knowledge which was used to identify needs and requirements for controlling access during simulator setup and firing.

Once customer expectations had been defined, ITT and H&N were integral in transforming these expectations into specific requirements that could be put into the system specification. ITT thoroughly reviewed the resultant specification, prior to release, to ensure traceability of customer expectations throughout the specification.

#### 3.1.5.2 Preliminary System Design

ITT's subcontractor, H&N, was funded to develop an initial design for an automated SSS system based on the requirements generated in the system specification. The intent of the H&N design was to specify the required locations for sensors, warning system components, controlled accesses, and SCIF setups. The H&N design was done so that the specification requirements could be transformed into actual design parameters, and also so that a design would exist for integrating into the existing building plans. A design was needed so that building requirements for providing space, power, conduit, and miscellaneous SSS hardware could be defined and included in the building design. H&N's design would also address the interface between simulator operation and control scenarios, and the SSS. ITT played an active role in ensuring that these simulator to SSS interfaces were adequately addressed, and in providing input into the integration of those two elements, and of the SSS design, within the facility. ITT provided continuous review and input to the evolving H&N design from initiation through 100% completion and approval by DSWA. Throughout the development process, ITT emphasized a system-

level focus during reviews so that overall facility requirements would not be compromised in any way.

3.1.5.3 Procurement Support

Although ITT recommended that the SSS be acquired through a competitive procurement, DSWA made a programmatic decision to use NISE East Charleston as the contracting agency for locating and hiring a vendor from their standing support vehicles to supply and install a safety and security system. NISE East had previous procurement experience with similar systems and could supplement DSWA in an area where DSWA experience was not extensive. ITT was intimately involved in assisting NISE East in preparing a procurement specification, and ensured that the traceability of customer expectations and system specification requirements was achieved.

3.1.5.4 Support to Design Maturation

Management Systems Associates (MSA) was selected as the SSS vendor. Once this selection occurred, ITT actively participated in the review and approval of the evolving system design layout. ITT thoroughly evaluated the design to include equipment layouts, wiring diagrams, and proposed hardware lists. Observations garnered from these evaluations were fed back to NISE East to be provided as input to the vendor. Throughout this process, ITT focused their review from a systems level standpoint to ensure the integrity of the facility was not compromised in any way.

Another objective of ITT's review was to ensure that the equipment proposed by the vendor met the requirements and expectations generated by the customer. In some cases, items fell short of intended requirements. In these instances, ITT analyzed the impacts and made the DECADE community aware of discovered shortfalls. We also actively participated in trade-off discussions and analyses to ascertain what was to be done in response to these shortcomings. We believe that effective work-arounds or trade-offs were achieved in all cases, resulting in a system flexible enough to satisfy all requirements of AEDC and the testing community. ITT actively participated in this review process from initial design layout submittals, through the review and approval of a 100% installation design package.

3.1.5.5 Technical Analyses

While the majority of components selected for the SSS were commercial off-the-shelf items, the peculiar operational constraints of the DECADE facility required technical analysis to ensure operability of the SSS. Special considerations included the radiation environment and large amounts of electrical energy.

3.1.5.5.1 Radiation Susceptibility Analyses

ITT provided our estimates of radiation fields at each access point of the test cell to NISE East so that installed components could be assessed with regard to shielding from ionizing radiation and from the effects of currents generated by the electromagnetic pulse. These data were incorporated into the component specifications.

3.1.5.5.2 Operational Cost-Benefit Analyses

ITT worked with AEDC DECADE personnel to assess the long term cost benefit of various alternative access control technologies for incorporation into the SSS. We gathered operational capabilities for portal monitoring systems from Sandia Laboratories, as well as for proximity and magnetic stripe card readers. Each of these technologies was evaluated in combination with keyed access controls for use to monitor staff movement in and out of the test cell and other limited access areas in the facility. Based on these analyses and the development of operational procedures, test cell access is now controlled by a combination of proximity card readers and key pad controllers.

3.1.5.6 Coordination/Resolution Of Installation Issues

One of ITT's primary integration tasks was to handle on-site coordination of all elements being installed into the DECADE facility, to include the installation of the SSS. ITT personnel were on-site to handle integration-related problems that arose on a daily or weekly basis. ITT worked to resolve these issues in an expedient manner so that impacts to element costs or installation schedules were kept to a minimum.

One effort involved review of the proposed SSS equipment layout and the correlation of that design with the building provided conduit and power locations. This analysis resulted in recommendations to the contractor on more efficient ways to utilize existing building resources by changing some of the proposed wiring schemes and equipment locations. It also provided the contractor with advance notice of where building supplied conduit and power would not meet his intended needs. This allowed for early identification of work-arounds so that installation schedules were not impacted.

Another similar analysis centered on coordinating the number and locations of RF penetrations into the internal Sensitive Compartmented Information Facility, the Simulator Control Room, and the UDAS Shielded Enclosure areas. ITT gathered inputs pertaining to penetration requirements from all appropriate elements, SSS included, and then ensured that building designs and construction reflected adequate provisions for both fiber and low voltage filters. When lags in the construction of these rooms began to affect SSS installation, ITT took initiative to identify work-arounds so that SSS installation schedules were not impacted and their work could continue.

ITT worked with PPI and MSA to identify the wiring requirements for the simulator abort and manual test cell lockout systems. Since wiring for these systems would share conduit with the SSS system, ITT worked to coordinate an MSA one-time installation of all required wiring. They actively pursued this effort on-site to ensure all wiring was correctly installed and in place. This resulted in a modest cost savings since wiring only needed to be pulled in these areas one-time, and eliminated the installation difficulties PPI would have faced in attempting to pull wiring through already occupied conduit.

Final SSS installation was delayed several months due to incomplete building construction. ITT kept NISE East apprised of conditions through timely status reports. Once NISE East personnel and their contractors were on site, we coordinated the

subsequent phases of installation with AEDC organizations, including the various building contractors, the UDAS installation workers, and base security contract workers to minimize interference. Prior to arrival of NISE East technicians, ITT personnel inspected and documented critical interfaces for the SSS cable plant into the Shielded Enclosures and the Control Room. To maintain quality control and traceability to DECADE requirements, ITT inspected installation of the SSS during construction and produced and tracked the final installation punch-list. We arranged for the participation of Holmes & Narver, our security systems subcontractor, during the final acceptance test. This inspection lead to the final onsite construction phase by NISE East to make final repairs and prepare PPI interfaces adequately. As integrator, ITT mediated meetings between AEDC and NISE East to discuss and resolve discrepancies and plan remediation. Finally, we documented training received by AEDC.

### 3.1.6 Interface Development

Precise interface design and definition is essential to the successful development of any project, but especially one like DECADE where each component developer retained considerable autonomy. Interfaces must be identified, designed, developed, evaluated, and controlled. ITT developed an interface control process, described later in this report, to help ensure that the fully integrated system would function properly. ITT was also instrumental in the actual design and development of several interfaces. This section describes the activities of ITT in designing/developing some of the more critical system interfaces.

#### 3.1.6.1 Simulator Control Room RF Penetrations

As mentioned above, ITT played a key role in the design/development of the interface scheme for providing penetrations into the simulator control room. ITT hosted several requirements meetings and coordinated with all appropriate element engineers to define the scope of the requirements for RF filtered penetrations. The need was quite extensive totaling in excess of 1000 penetrations. ITT met with the contractor constructing the control room and developed various alternatives for providing a design that allowed space and access for the needed penetrations. Through trade-off analyses, ITT determined that a removable patch panels, with a set number of planned penetrations per panel, best suited the needs of the community. This design scheme permitted each element designer to create his own penetrations. Removable panels would allow for easy machining of those holes. ITT went further by allocating specific space on each panel for use by a particular element. This was done by taking the element provided penetration requirements and allocating them space on specific panels based on when the penetration would be performed, the type of penetration, and the location of equipment residing in the control room. Penetrations were summarily grouped by element. ITT also coordinated between elements to clearly define who would be creating a specific penetration, when the creation would occur, and in some cases, which additional elements would utilize the penetration. The latter concerned fiber interfaces where multiple fibers could pass through one penetration. ITT made sure that adequate documentation of the interface was created, to

include sketches, and disseminated this information throughout the DECADE community.

#### 3.1.6.2 UDAS Shielded Enclosure RF Penetrations

ITT also had a key role in the design and development of RF filtered penetrations into the UDAS Shielded Enclosure. In order to preserve the ability to electrically isolate the enclosure, no electrical penetrations were allowed. The shielded enclosure contractor was required to provide 12 spare fiber waveguides for access to the shielded enclosre by other elements. ITT worked closely with the element engineers who required access to identify their needs for numbers of penetrations. We took the initiative to develop an optimal design for locating and utilizing the spare waveguides and prompted the design/development of waveguide "boxes" which were constructed by AEDC and attached on each side of the wall separating the shielded enclosure room from the electrical equipment room. These boxes were provided to the enclosure contractor for final installation. Throughout this effort, ITT made sure that all requirements for penetrations were addressed and traceable in the final design.

#### 3.1.6.3 Vacuum System Interfaces In The Basement Equipment Room

Finally, ITT was instrumental in the final design and development of interfaces between the Basement Equipment Room (BER) and the Simulator Vacuum System. The final vacuum system, selected for procurement and installation, differed considerably from the prototype system design used in developing the interfaces built into the BER. As a result, practically all of the BER interfaces had to be redesigned and developed. ITT worked with PPI, their mechanical and electrical subcontractors, and the vacuum system vendor to design interfaces appropriate for the system being installed. This involved redesign and analysis of interfaces for cooling water, compressed air, utility power, instrument power, and exhaust. In addition, ITT analyzed the effects of required changes in the existing building design for HVAC and fire suppression, and made sure that building functionality in these areas was not degraded in any way. ITT spearheaded early space allocation studies in the cramped BER, and provided valuable input to PPI regarding the final layout of equipment, cabling, and cable trays. ITT also took steps to ensure that adequate documentation was created to reflect all of these changes.

## 3.2 CONFIGURATION MANAGEMENT/INTERFACE CONTROL

### 3.2.1 Configuration Management

Structured configuration management (CM) practices, implemented during the design/development phase of a project, provide a myriad of benefits ranging from potential cost and schedule savings, to maintaining traceability of requirements throughout the design process. It also aids to ensure other program considerations and parameters, such as maintainability, reliability, functionality, and specification integrity are not compromised as design elements mature and change.

Utilization of sound configuration management practices is necessary to ensure that element and interface designs are controlled and well documented for future reference. A formal process must exist to ensure that all changes to baseline designs receive adequate attention, review, and ultimately, approval prior to their implementation.

### 3.2.1.1 Process

ITT instituted a process which provided the mechanisms whereby all changes were scrutinized at a level appropriate to the magnitude of the change. Through this structured control process, the DECADE program was ensured that assessments were made for impacts of the change on other elements, support systems, interfaces, structures, and subsystems. This enabled a beneficial focus on the entire system rather than on a specific element without regard to its system level impacts.

The participative review portion of the process resulted in cost and schedule savings by creating a forum where issues were identified, up front, instead of later in the development process where changes to more mature designs would have caused greater negative impacts to program costs and schedules. The process also enabled an environment where intelligent trade-offs could be made, by the appropriate parties, between the need for design changes and the effects on other program elements such as cost, schedule, and technical performance. This provided a sound basis for overall DECADE facility optimization rather than a concentration on localized optimums.

ITT also used this process as a means for ensuring and controlling that system level requirements were not compromised in any way without knowledge by all principal DECADE team players, most importantly DSWA. The process was integral for maintaining traceability throughout dynamic design processes. Rapidly changing designs were able to be tracked, and historical documentation was created throughout the design evolution process which ensured that valuable resources would not be spent in the future "readdressing" issues that had already been analyzed and decided upon.

The configuration management process implemented by ITT also served as a check against unplanned performance or functional degradation of the system. Through the structured controls and reviews inherent to the process, ITT was able to ensure that specification requirements were traceable through changes in the design, and that these system level requirements remained intact and were not compromised in any way.

#### 3.2.1.1.1 Scope Of Control

The CM program for DECADE ensured the establishment of baselines; provided traceability of change proposals, waivers, and deviations; and provided uniform change control procedures. The major activities involved in the program were: establishment of baselines and Configuration Item (CI) definitions; processing of proposed changes; establishing and recording all actions of the DECADE CM control process; and providing Configuration Management interface with all agencies associated with the development of DECADE.

#### 3.2.1.1.2 Controllable Items

The first step ITT undertook was the identification of the items deemed necessary to control. Under the guidance of MIL-STD-973, ITT defined controllable documentation as Class I & II engineering changes, specification changes, deviations, waivers, notices of revision, and interfaces. Critical to ITT's task at this stage, was to ensure that the documentation reflected all of the information required to adequately review, analyze, and evaluate a proposed change or modification. ITT utilized the guidance of applicable MIL-STDs, historical knowledge, brainstorming techniques, and other applicable processes to ensure that required information would be adequately reflected on future documentation of these controllable items. Criteria were created for determination of whether a proposed change constituted submission within the DECADE CM process. This criteria and the guidelines for control of these items is summarized below:

#### 3.2.1.1.3 Class I And Class II ECPS

Engineering Change Proposals (ECPs) were to be submitted for every change or modification proposed which deviated from the baseline design of the applicable configuration item. There were two classes of ECPs - Class I and Class II. Class I changes were those that affected form, fit, or function of a configuration item and/or had impact on one or more of the following: cost, safety, GFE, program skeds, interoperability with other CIs or equipment, contractual requirements, or warranties. Class II changes were those that had no effect on the design or function of other parts of the system hardware. These were submitted for information and documentation purposes only. All ECPs were prepared in accordance with the ECP form and instructions created by ITT.

#### 3.2.1.1.4 Specification Change Notices

A Specification Change Notice (SCN) was the document used to propose, transmit, and record changes to a specification. The change may or may not have been associated with an ECP or design change. The proposed SCN was used to convey the details of the change, and referred to the exact wording within the specification that was to be replaced, or to the exact location where additional information was included. After approval, the SCN was considered part of the specification and superseded all of the previous information and requirements that it replaced. SCNs were to be prepared in accordance with the SCN form and instructions created by ITT.

#### 3.2.1.1.5 Deviations And Waivers

Deviations and waivers to the requirements of the specification were to be handled similar to SCNs. Deviations were temporary departures from performance or design requirements, drawings, or other contract documents. Waivers were one time approvals to depart from the specification requirements if a particular element of a CI was deemed acceptable. Waivers and deviations were to be prepared in accordance with the forms and documentation created by ITT.

#### 3.2.1.1.6 Interfaces

Interfaces were documented in the Interface Control Document (ICD). Control of interfaces was accomplished by default through the control of Class I changes. Changing an interface in a way that affected any of the criteria of a Class I change meant that the item became controllable and had to be subjected to the formal CM process. Interfaces were primarily developed by ITT, however, anyone who had established a need for an interface that had not been documented could submit an ICD sheet to the PM for consideration. Interface Control Data Sheets should be prepared in accordance with the format created by ITT.

#### 3.2.1.1.7 Approval Process

ITT was responsible for delineating and defining a process for review and approval of all controllable items. Key to that process was recognition and assignment of ultimate approval authority to the DSWA DECADE Program Manager. The PM was the final approval authority over all Class I engineering changes, SCN submittals, Interface modifications, and other revisions to controllable documentation which meet the requirements of a Class I change.

ITT also established a Configuration Control Board (CCB) to serve as part of the review and approval process. The CCB provided recommendations to the PM for all controllable documentation requiring approval. The purpose of the CCB was to provide an independent assessment on configuration related issues, derived from the programmatic and technical experience and expertise of its members. Membership was selected from key organizations within the DECADE team, and the ITT Project Manager served as chairman.

ITT was responsible for disseminating all submittals of baseline documentation modifications for appropriate review and comment by cognizant DECADE team members. They also served as the focal point for all responses arising from this review. They also served as liason with the CCB members to provide them with an organized presentation of the inputs received during the review process. ITT recorded the results of any approval/ disapproval of submitted documentation by the DECADE Program Manager, and served as a repository for all submittals. ITT also reported, to all affected parties, the results of the DECADE Program Manager's configuration management actions.

All other organizations and working groups, who were part of the DECADE program team, provided technical and programmatic input, when requested, on any baseline documentation modifications that were submitted for approval.

The change control process implemented by ITT involved identification, submittal, review, approval, coordination, and revision. A configuration control flow chart summarizing this process is shown in Figure 3-1. ITT also developed a unique numbering system for tracking and providing traceability of proposed changes.

| Start (Working Days) | Organization | Responsibilities |
|---|---|---|
| t = 0 | Originator | - Identify and submit change<br>- Prepare NORs |
| t = 10d | SI | - Assign numbering<br>- Distribute to DECADE Team<br>- Provide integration assessment |
| t = 12d | DECADE Team | - Review change<br>- Provide inputs |
| t = 25d | SI | - Collect Responses<br>- Aggregate inputs for CCB and PMO |
| t = 30d | CCB | - Perform independent assessment<br>- Provide recommendation to PMO |
| t = 35d | DECADE PMO | - Final Decision<br>- Initiate Contract Modification<br>- Notify of disapproval |
| t = 37d | SI | - Place copy in repository<br>- Document and report PMO CM actions<br>- Copy of approved submittal to originator |
| t = 40d | Originator | - Update documentation<br>- Distribute updates |

**Figure 3-1. Configuration Control Process**

### 3.2.1.2 Implementation

#### 3.2.1.2.1 Configuration Management Plan

ITT developed a Configuration Management (CM) Plan for the DECADE program to facilitate implementation of the CM process. The plan was approved by the DSWA DECADE Program Manager and became the guiding program documentation for how CM was to be implemented and performed on the project. The document defined the structure, organization, responsibilities, processes, and controls to be utilized in conducting CM. The plan adhered to all applicable military standards and was tailored to the specifics of the DECADE acquisition life cycle.

Contained in the plan were the specific criteria that defined controllable items and documentation. ITT created all of the formats and instructions for the forms required to carry out the CM process, and included these as appendices to the document. Each organization's roles and duties under the CM program were clearly defined in the plan. Process flows were created to show how expected review and approval processes were to be carried out. These flows are shown in Figures 3-2 through 3-4.

ITT created annexes to the plan as unique CM requirements dictated their inclusion. Detailed process flows were created to show how the CM submittal, review, and approval process would work, on-site, during installation of various CIs within the facility. These annexes included details regarding responsibilities, structures, and controls for these newly CM governed situations. Their inclusion helped to ensure that functionality and performance of the facility was not compromised, and that all installation related changes were adequately documented for future reference.

ITT, though not primarily responsible for building CM, played an active role in defining proposed changes, and in tracking the status of the Corps of Engineers CM process so that the entire DECADE team was aware of the status of CM for the entire project.

ITT developed process flow charts and briefings which were presented at Integration and Test Working Group (ITWG) meetings to educate DECADE team members on the requirements of the CM program. ITT also provided each organization with a copy of the approved CM plan and all subsequent additions and changes to the plan. The process defined in the CM plan was discussed in open forum so that all team members could provide inputs into where and how the CM process could be improved, and to garner group commitment toward achieving the objectives of the DECADE CM program.

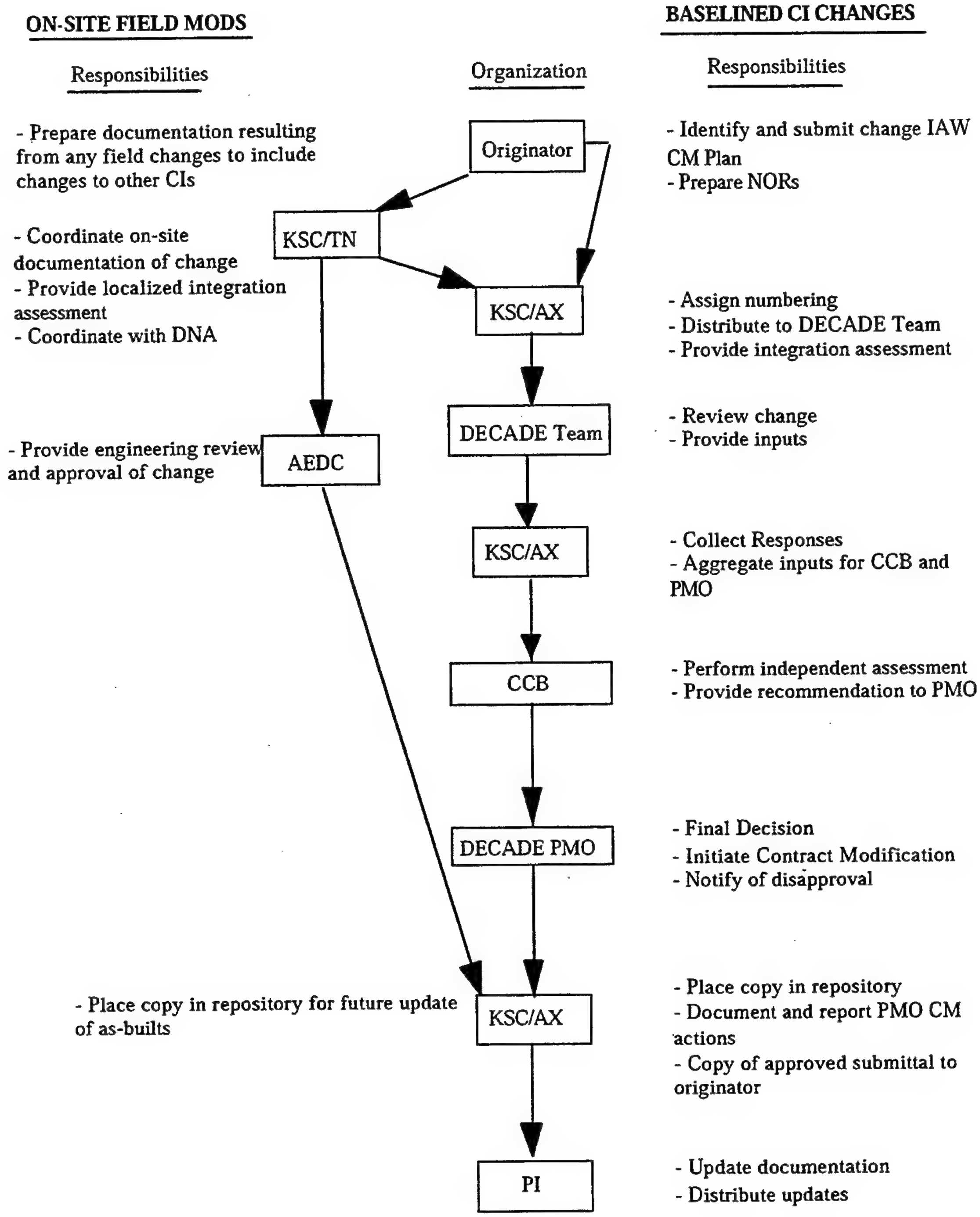



**Figure 3-2. Physics International CM Process**

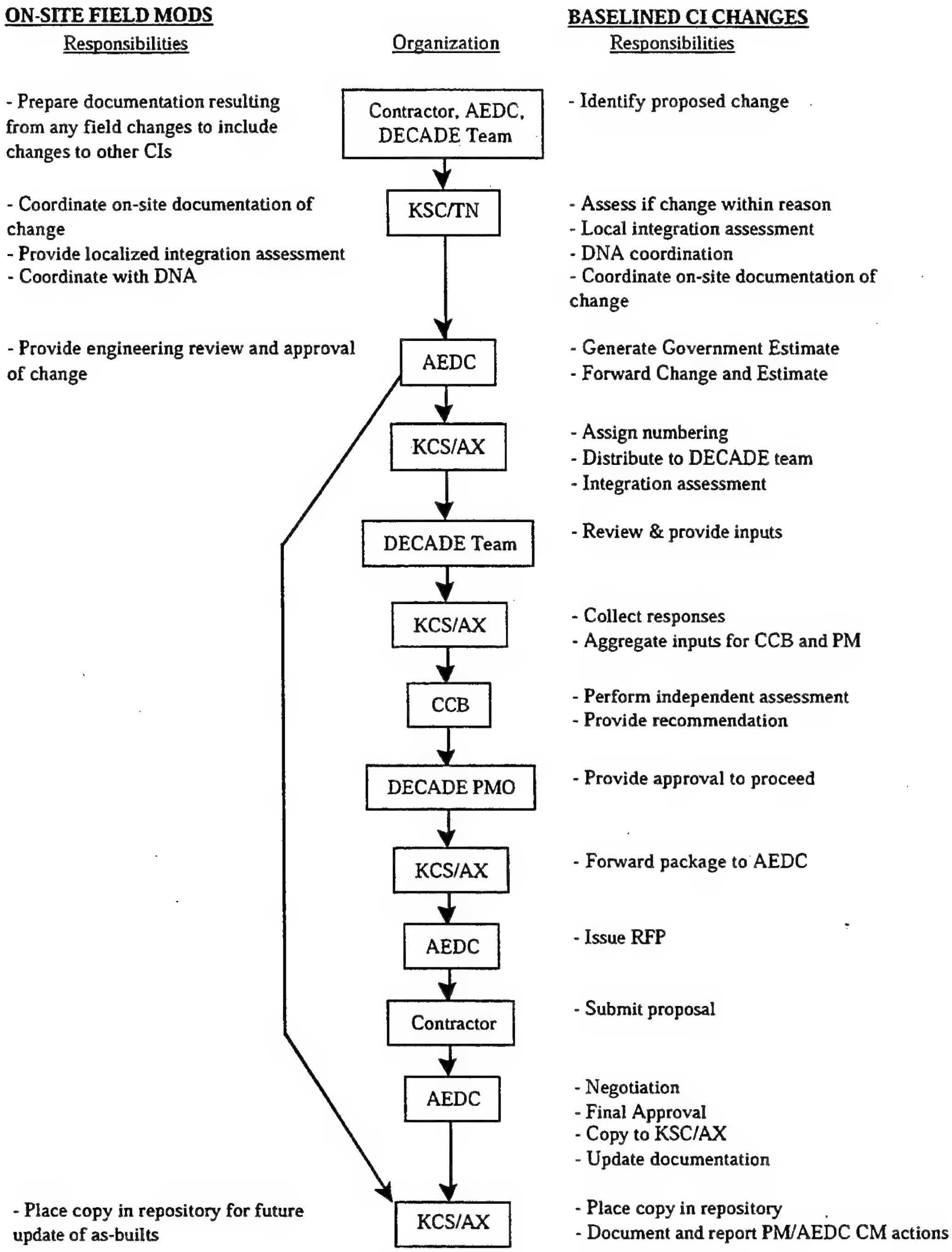



**Figure 3-3. AEDC CM Process**

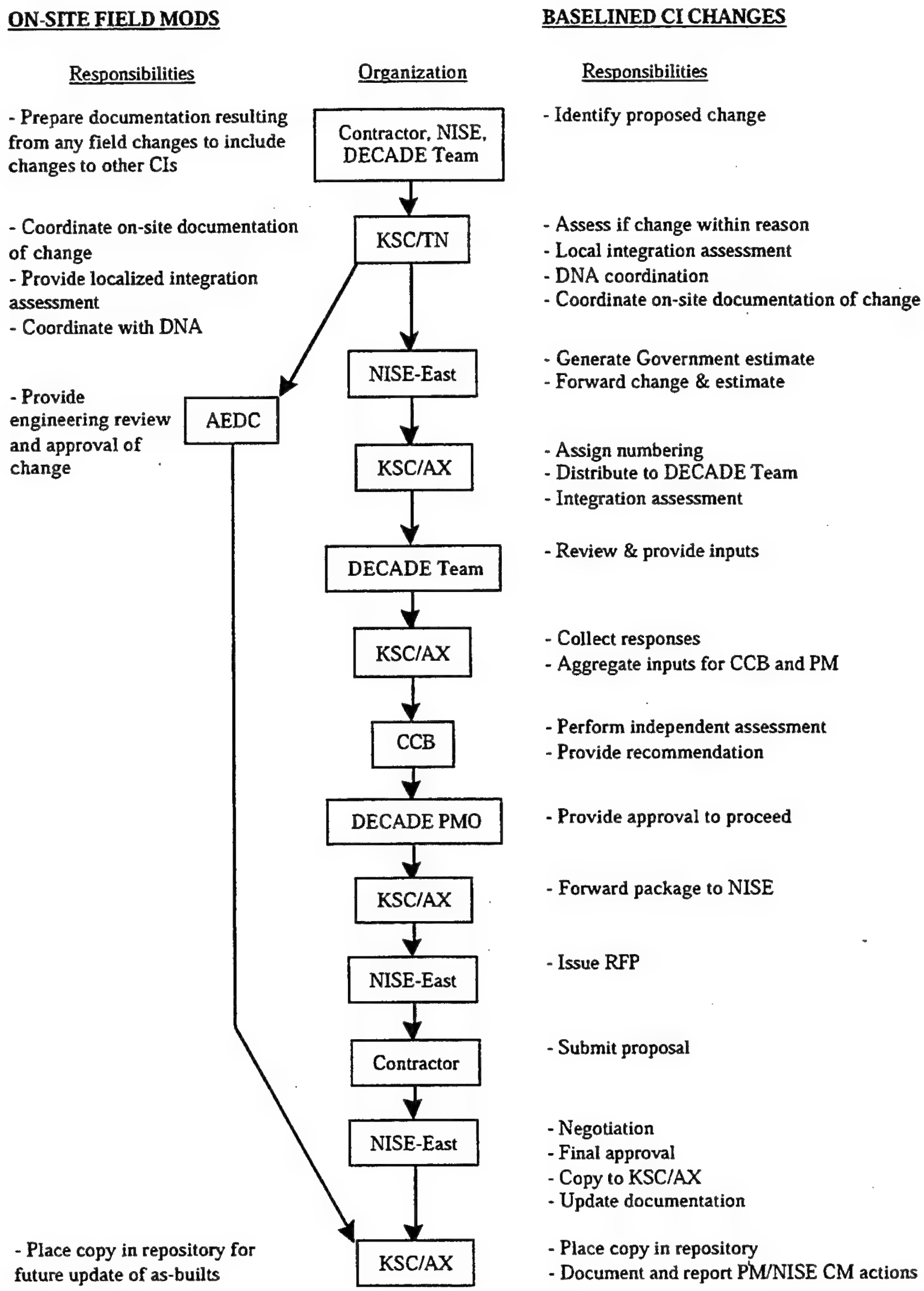



**Figure 3-4. NISE East Organizations CM Process**

#### 3.2.1.3 Maintenance

ITT was responsible for the administration of the DECADE CM program, once implemented. As part of this responsibility, ITT served as the facilitator and coordinator of all CM-related activity. ITT also provided technical review and inputs on all proposed changes, focusing on systems integration and system-level type analyses. This ensured that all impacts, to each and every CI, were evaluated from a system level and that emphasis on the "big picture" was maintained. Finally, throughout the function of the CM program, ITT served as the central repository for all CM documentation and related information. This ensured that all applicable documentation could be utilized for future reference when required.

### 3.2.2 Interface Control Document

Precise interface definition is essential to the successful development of any project. Interfaces must be identified, defined, evaluated, and controlled. The interface control process must ensure that engineering changes are correlated between multiple development agencies and that the fully integrated "system" functions efficiently. It is essential that all affected parties be aware of their responsibilities to interfaces. Increased program costs and undesirable schedule impacts will result from any failure to recognize the importance of interfaces and their key role in design and development processes. Integration becomes even more critical to a project's success as the program continues toward an eventual IOC. There can be no surprises when the physical integration of program elements begins. A successful project requires documentation and resolution of all interface related issues prior to that time.

#### 3.2.2.1 Process

ITT, as the systems integration contractor, established a control philosophy centered around the creation of an Interface Control Document (ICD). This document served as the primary management tool for recording and resolving issues related to interfaces between Configuration Items (CIs). The document ensured that the complete characteristics of an interface, including functional and physical requirements, were published and made known to all concerned. It served as a single location where the details of all interfaces resided.

ITT utilized the ICD as a dynamic document and useful management tool. The document was constantly monitored and updated to reflect the latest detailed designs associated with specific interfaces. ITT also continuously assessed all interfaces to determine if issues were developing that impacted other CIs or system level requirements. ITT created a unique process for "flagging" issues and risks associated with interfaces, and utilized that process for resolving interface related issues in a timely manner. The maintenance of the ICD also enabled ITT to readily see where details were lacking or information needed to be clarified so that corrective action could be taken. Interface progress was constantly monitored and reported upon to the DECADE team using the information provided through the maintenance of the ICD.

ITT routinely distributed updates of the ICD to the DECADE team members who found it to be a very valuable tool. The ICD provided interested parties with information regarding the design details of both sides of an interface. This enabled design teams to review the details of what was being provided on the "other side" of their interface. It allowed team members to resolve identified incompatibilities at an early stage, and to reduce the overall risk associated with the integration of their own designs within the facility.

#### 3.2.2.2 ICD Characteristics

The initial step, ITT undertook as part of the creation of an ICD process, was the definition and determination of the type of characteristic data that should be collected to fully identify and define an interface. The goal was to document the information needed to facilitate proper designs and eliminate the risk of incompatibilities between integrating elements. ITT used engineering judgment, experience, and historical data to arrive at the following characteristics that were used to document each interface associated with the DECADE project.

**Physical/Functional Characteristics:** These were included because of their necessity for providing the details needed to complete element designs. They also enabled resolution of what each party's responsibility was to the interface in terms of hardware, signals, etc. These fields were the source of information used to identify the types of verification needed for each interface as well.

**Responsible Parties:** These were included so that specific points of contact could be established for each interface. This was beneficial to the design teams who needed POCs for sharing information, and also during the resolution of any issues which may have been identified regarding a specific interface.

**Reference Documentation:** This information was included so that interested parties were aware of the information sources used to describe the functional/physical characteristics of each interface. It also provided reference of where to go if visual representation (i.e. drawings, sketches, etc.) of an element of an interface was desired.

**Numbering/Cross Reference:** This information was based on a numbering hierarchy created by ITT which was derived from CI Work Breakdown Structures (WBS). It was included to provide a logical numerical representation of all of the project's interfaces for indexing, cataloging, and record keeping purposes.

**Comments/Status:** This was a free text field where issues and required actions could be listed for each interface.

3.2.2.3 ICD Implementation

3.2.2.3.1 Interface Identification

ITT's process of interface documentation and control commenced with the identification of interfaces that existed between the configuration items associated with the DECADE project. ITT used its active participation in design reviews, requirements meetings, and specification preparation and reviews as a primary means for identifying and gathering data associated with interfaces. ITT also used its intimate familiarity with element designs and documentation to pinpoint and define where interfaces resided. As much pertinent information was gathered as was available. Data was collected and parceled to support documentation of the characteristics deemed essential in fully defining an interface.

3.2.2.3.2 Data Manipulation

ITT utilized a relational database for storing and manipulating the vast amount of data that was collected. The database was extremely useful in support of grouping and organizing the information gathered. ITT used the report generation function of the database in the creation of an ICD form which contained fields for each of the characteristics associated with an interface. See Figure 3-5. Each specific interface had its own form, and the culmination of these sheets represented the body of the ICD. ITT utilized the relational portion of the database to generate queries that proved beneficial for tracking interface progress and in targeting interfaces with issues which required resolution.

**INTERFACE CONTROL DATA SHEET**

**Authorized Acceptance:** ______________________ **Date:** __________

**Authorized Acceptance:** ______________________ **Date:** __________

**Interface Maturity:**

**Date of Entry:**

**Interface Status:**

**Interface Control Item Identifier:**

**Interface Title:**

**Reference Documentation:**

**Responsible Engineers:**

**Interface Description:**

**Functional Interface Characteristics:**

**Physical Interface Characteristics:**

**Verification Method:**

**Comments:**

**Figure 3-5. Interface Control Data Sheet**

ITT devised a unique numbering system for each interface based on the WBSs of the CIs involved. Where a WBS was not available for a CI, ITT created one. Each interface involved two or more CIs. An interface number consisted of the appropriate WBS number of one CI, followed by the appropriate WBS number of each additional CI associated with the interface. This created a unique numbering for each interface and enabled the logical cataloging and recording of each interface for tracking and reference purposes. Familiarity with the WBS hierarchies also allowed for quick recognition of the CIs involved in an interface simply by examining the interface number. Through this numbering system, ITT was able to logically divide the ICD into sections for quicker reference.

3.2.2.4 Control

3.2.2.4.1 Internal Management And Control

ITT developed a unique process for assessing interface risks by modeling the procedures and criteria presented in Air Force Material Command Pamphlet 63-101, dated 15

September 1993, to develop risk probability and consequence factors tailored to the characteristics and requirements unique to interfaces. ITT went further by developing a two-tiered management color coding scheme, derived from the numerical results of the interface risk assessment, to assist in identifying those interfaces with high risk and in need of immediate management attention. ITT used that tool to flag problem areas, and as a basis for developing mitigation plans to resolve outstanding issues associated with troublesome interfaces. The tool was an integral part of the procedures established to control and manage program interfaces.

#### 3.2.2.4.2 Methodology

ITT developed a model based upon the criteria necessary to fully assess the risks associated with any interface between two elements. Those criteria include the requirements, engineering/design, physical characteristics, and verification of an interface. Risk can be directly correlated to the extent to which these criteria are understood for a particular interface. The criticality and maturity of an interface play a key role in any determination of risk as well. ITT's model accounted for the need of interfaces to mature as the designs of associated elements mature; and ensured proper attention was given to the relationship between interfaces and associated program costs and schedules.

Application of the tool is similar to that of the techniques outlined in 63-101. Probability factors are developed and assigned to subsets of each of the criteria used to assess interfaces. See Figure 3-6. The requirements, design/engineering, physical characteristics, and verification of an interface are examined and appropriate probabilities assigned. The maturity of an interface is based solely on the design maturity of its associated elements. As designs mature, the weighting associated with interface maturity is increased. This ensures that any issues associated with an interface are surfaced and work-arounds facilitated as part of element designs prior to their becoming too solidified. The interface is also assessed in terms of its potential impacts to program cost and schedule. Those interfaces with greater potential impact are assigned higher numerical weightings. Again, this allows issues to be surfaced prior to a time when they might detrimentally impact program or element costs and schedules.

| Physical Characteristics | | Verification | |
|---|---|---|---|
| - Both sides of interface well documented and fully defined | 0 | - Verification method identified and documented. (e.g. Included as part of a test plan, required submittal, etc.) | .1 |
| - One side fully documented, the other generally understood, however, some detailed information still required | .3 | - Verification method identified and uncomplicated (i.e. Visual inspect, etc.). Process needed for execution. | .3 |
| - Only one side of interface adequately documented, including details | .5 | - Verification method identified. Process for execution undefined | .5 |
| - One side of interface generally understood. All details lacking. | .7 | - Method of verification complicated and not well defined. | .7 |
| - Physical characteristics of interface ambiguous | .9 | - No method of verification identified. | .9 |
| **Design/Engineering** | | **Requirements** | |
| - Design is industry standard and/or design analysis is complete | .1 | - Fully defined. Both sides have documented needs and expectations | 0 |
| - Much of the analysis is complete on a fairly simple design | .3 | - One side defined. The other has established general concept, however, a few minor areas still require definition | .3 |
| - Some secondary analysis remains on a fairly complicated design | .5 | - Moderate amount of definition still required from one side. | .5 |
| - Some key analysis remains on a fairly complicated design | .7 | - Moderate amount of definition required from both sides | .7 |
| - No analysis has been completed on a fairly complicated design | .9 | - Requirements of interface unstated | .9 |
| **Maturity** | | **Criticality** | |
| - Neither Item through CDR (White) | .1 | - No effect on element cost or schedule. No effect on element performance | .01 |
| - Neither item through CDR, however, at least one < 2 months away | .3 | - Increase in element cost or schedule, but not system schedule; and/or element performance slightly degraded | .1 |
| - One item through CDR (Blue) | .5 | - Increase in element sked affecting intermediate milestone but not system sked; and/or degradation to element performance | .3 |
| - One item through CDR, the other < 2 months away | .7 | - Minor increase to system sked (< 10%); and/or minor decrease in system performance | .5 |
| - Both items through CDR (Purple) | .9 | - Moderate increase to system sked (< 40%); and/or moderate decrease in system perf. | .7 |
| | | - Major increase to system sked (> 40%); and/or major decrease in system performance | .9 |

**Figure 3-6. Interface Risk Probability and Consequence Factors**

Probabilities associated with each of the assessed criteria are summed, and this sum is multiplied, individually, by the maturity and criticality weightings which were assigned.

These two products are then summed to develop an overall numerical rating. The numerical ratings for all existing interfaces were then plotted, and boundaries set for the assignment of management color codings. These color codings, red, yellow, & green, provide an indication of where troublesome interfaces are occurring, and direct management attention to the resolution of those issues. As designs change, the assessments can be repeated and management efforts targeted to those interfaces where it is most needed.

3.2.2.4.3 Application

ITT applied this model extensively to all of the interfaces associated with the DECADE project. It was the primary means for identifying issues and risks associated with interfaces. When an interface was "flagged" as containing issues or discrepancies, ITT took steps toward resolution.

Resolution of issues was handled on a daily basis between ITT and the specific POCs associated with a targeted interface. In most cases, issues were resolved and adequate work-arounds achieved. In addition to daily team interaction, ITT presented the Integration and Test Working Group (ITWG) with a monthly briefing regarding the status of issue resolution for the most critical interfaces. Appropriate team members were generally assigned a formal action item for resolution of these issues to ensure that appropriate action was taken in a timely manner, and so that follow-up status could be provided, in open forum, to the entire team.

3.2.2.5 Maintenance

ITT was responsible for the administration and upkeep of the ICD and associated interface control processes. As part of this responsibility, ITT served as the facilitator and coordinator of all interface-related activity to include documentation of newly developed interfaces and resolution of any issues associated with interfaces. ITT took initiative to independently review design review documentation and drawing packages, and to conduct on-site inspections of work completed, to gather information used to update interface documentation. ITT also provided technical review and inputs on all interfaces, and ensured that systems integration and system-level type analyses were part of the review process. This ensured that all impacts, to each and every ICD, were evaluated from a system level and that emphasis on the "big picture" was maintained. Finally, throughout the function of the DECADE project, ITT maintained control over all modification and changes to interface documentation, and provided DECADE team members with frequent updates to the ICD. This ensured that the latest interface related details were available to support the daily activities and design processes of all organizations.

Although we updated the ICD periodically, making the UDAS Shielded Enclosure a separate project created a multitude of interface issues. Most were very minor, while others resulted in significant effort. Two examples of significant issues include shield room penetrations and the "architectural" wall surrounding the Shielded Enclosure. By

design, Lindgren needed to penetrate the enclosure and provide waveguide feedthroughs for communication systems signals. NISE East Charleston and AEDC also needed penetrations for fibers to enter the room. The SSS requirements were fairly straightforward, but getting AEDC to finalize their UDAS requirements was difficult. By focusing on the interface definition requirements generated by the ICD tool, ITT was finally able to highlight the significance of this documentation and to pass along an integrated set of requirements to Lindgren. Though not part of the Shielded Enclosure project, the same situation was true for the "baby SCIF," except it was complicated further by the need for low voltage filters. Again, we coordinated requirements with all parties and ultimately achieved success. In this case, we also had to coordinate directly with the RNJ subcontractors, since it was not possible either for ITT or the Corps of Engineers to enforce this aspect of the RNJ prime contractor role.

# 4. SYSTEMS ENGINEERING/MANAGEMENT

## 4.1 SYSTEMS ENGINEERING INTRODUCTION

### 4.1.1 Security Requirements

ITT has worked with AEDC and DSWA to ensure that the DECADE facility can support the security needs of any NWE facility user. DSWA made a Secure Compartmented Information Facility (SCIF) a design requirement from the very beginning. The user questionnaire we prepared for DSWA (See Section 7.2) confirmed that some potential users would benefit from having a SCIF.

Just prior to the 30% building design stage, LAN requested details on building security requirements. As a result of H&N's experience with designing secure facilities, AEDC requested their assistance in defining the security requirements. A preliminary meeting was held at AEDC to focus on three areas: SCIF, TEMPEST and access control. H&N asked AEDC questions to clarify the threat and top-level operating scenarios, allowing them to identify the construction practices levied by DIAM 50-3. H&N's understanding of the regulations also helped AEDC decide what level of TEMPEST protection was needed and for what rooms. The outcome of this meeting was passed on to LAN, and ultimately incorporated into the design. To operate the SCIF most efficiently, AEDC requested the building design include an automated access control system. H&N has designed and installed similar systems for facilities throughout the country. At this early stage, they advised AEDC on the top-level requirements for this system. They eventually developed a detailed design for what came to be known as the Safety and Security System (See Section 3.1.5).

As the building design progressed the ITT team helped AEDC evaluate security options for the entire User Area. They were considering a wide range of options at that time, from eliminating SCIF requirements altogether and retrofitting when the need presented itself to constructing and accrediting the entire area as a SCIF. We conducted several brainstorming sessions with AEDC to make sure they were fully aware of the pros and cons of each alternative. The outcome was the SCIF within a SCIF concept. AEDC will likely seek certification of the interior SCIF shortly after IOC. This will provide an area for closed storage of SCIF material and offices and a conference room. Since this area is being constructed as an RF enclosure, a user will be able to readily conduct classified computing. The remainder of the user area (the User DAS Room, User Set-Up Room and additional offices) was constructed to SCIF standards, but will only be certified on a temporary basis, if and when it is needed.

ITT's frequent questions and requests for information ensured security requirements did not fall through the cracks. We ensured that AEDC thought through the SCIF certification process and that the milestones were achieved. Also, as H&N developed the detailed design of the SSS, we asked AEDC questions about detailed operating procedures for the facility. Though we were not entirely successful in obtaining all the data we wanted, the design is flexible enough that major modifications should not be required as AEDC

develops those procedures. Additionally, security regulations evolved while the project was in mid-stream. DIAM 50-3 was superseded by a less stringent DCID 1/21. ITT made certain that AEDC understood the impacts of this change and that when appropriate, construction was modified to reflect the new requirements. Several minor cost savings were achieved because of the reduced requirements.

### 4.1.2 Compatibility Assurance Interfaces

One of ITT's primary responsibilities during the conduct of the DECADE facility development program was to ensure compatibility between all of the Configuration Items (CIs) associated with the project. To properly do so, ITT had to first identify all of the interfaces that existed between the many DECADE elements. ITT used its active participation in design reviews, requirements meetings, and specification preparation and reviews as a primary means for identifying and gathering data associated with interfaces. ITT also used its intimate familiarity with element designs and documentation to pinpoint and define where interfaces resided. As much pertinent information was gathered as was available. Data was collected and parceled to support documentation of the characteristics deemed essential in fully defining an interface. These interface documents were subjected to the control process ITT established, as outlined in section 3.2 of this report. ITT also conducted systems engineering analyses of all proposed interfaces as part of ensuring compatibility with the facility and other configuration elements.

ITT reviewed all design documentation and specifications from a systems engineering standpoint to ensure compatibility between element designs. Building-provided systems for compressed air, electrical power, and cooling (water and HVAC) were assessed in terms of their capacities and input properties (flow rates, temperatures, etc.) to substantiate their ability to satisfy interface requirements on both an individual and facility system level. Base support interfaces were assessed to ensure that the facility requirements for water, steam, communications, fire support, and power were met and provided at acceptable levels to meet facility requirements. Simulator interfaces, to include auxiliary systems, were analyzed from a systems engineering standpoint which included evaluation of planned physical attachments and functional requirements. Discrepancies between what was designed and what was actually being provided were identified so that designs could be altered and successful integration achieved.

ITT's system engineering activities also included overall system analyses to ensure facility level requirements were achieved. ITT actively participated in the design of the Safety and Security System (SSS) and Shielded Enclosure to ensure overall requirements were addressed by these designs. ITT actively reviewed the installation design packages of both from a systems level to ensure smooth integration within the existing facility. Interfaces were examined from physical and functional perspectives to make sure that the facility and these element designs were compatible. Again, problems were identified at the earliest stage possible so that designs could be corrected and compatibility of these systems with the facility ensured.

### 4.1.3 Human Factors Analysis

ITT conducted human factors analyses to ensure the DECADE design met code requirements while serving as a useful facility to the tester. The handicapped personnel lift is a good example of the human factors value added by ITT. In one of the early reviews of LAN's DECADE building design, our A&E subcontractor H&N identified that LAN's design was potentially non-compliant with handicapped personnel access requirements. H&N researched the issue with the National Handicapped Access Board to determine the specific requirements for handicapped access in a special-purpose test facility like DECADE. H&N determined that a handicapped personnel lift was, in fact, required; these requirements were passed back to LAN, through DSWA and the Army Corps of Engineers. By identifying this design deficiency early in the design process, ITT/H&N was able to influence the design prior to the Corps releasing a complete bid package. This avoided potential future design changes or construction change orders.

The bulk of ITT's human factors analyses were associated with the system safety hazard assessment activities conducted by ITT and our A&E subcontractor, H&N. These analyses are discussed in greater detail in Section 4.1.8.2.

Early in the building design process, ITT advised DSWA and AEDC to incorporate standards of occupational safety into the radiation shielding for the building. AEDC and DSWA elected to adopt the more stringent protection requirements for exposure of the general population. This dose level was used in all subsequent radiation safety analysis. While this decision added to construction costs, it avoided potential future building

**Table 4-1. DECADE building structural modification recommendations and issue identification**

| |
|---|
| **Thrust Column**<br>– Column reinforcement.<br>– Omit topping slab to allow monitoring of column stresses. |
| **Slab Under Shielded Enclosure**<br>– ECP 53 to mitigate shear problem on two northernmost openings to the tunnel. |
| **Rail Beams**<br>– Load bearing capability of back 10 feet of rails is lower than the rest. |
| **Perimeter Trench**<br>– Grating covering trench will support 820 lbs concentrated over a 12" x 12" contact area; it will not support a truck or loaded forklift. |
| **Area Behind Quad 2**<br>– Concentrated load bearing capacity is lower than the rest of the slab; capacity must be considered in the placement of crane outriggers. |

modifications that might result from Tennessee adoption of the most restrictive radiation

protection standards. Once this decision was made, ITT supported all radiation safety analyses using the stricter requirements.

### 4.1.4 Design Integrity Analysis

ITT helped DSWA and AEDC ensure that DECADE's design met system and user requirements, was user friendly, and operated with minimum costs. ITT provided an independent review of the UDAS hardware and software design to ensure that the design met requirements and considered reliability and maintainability. In other instances, ITT employed A&E subcontractor H&N to review LAN, NISE East, and other designs to ensure all aspects of structural, code, and user requirements were adequately addressed. The structural and radiation shielding analyses are described in more detail in the following subsections. Other, more specific, activities are discussed under the appropriate sections.

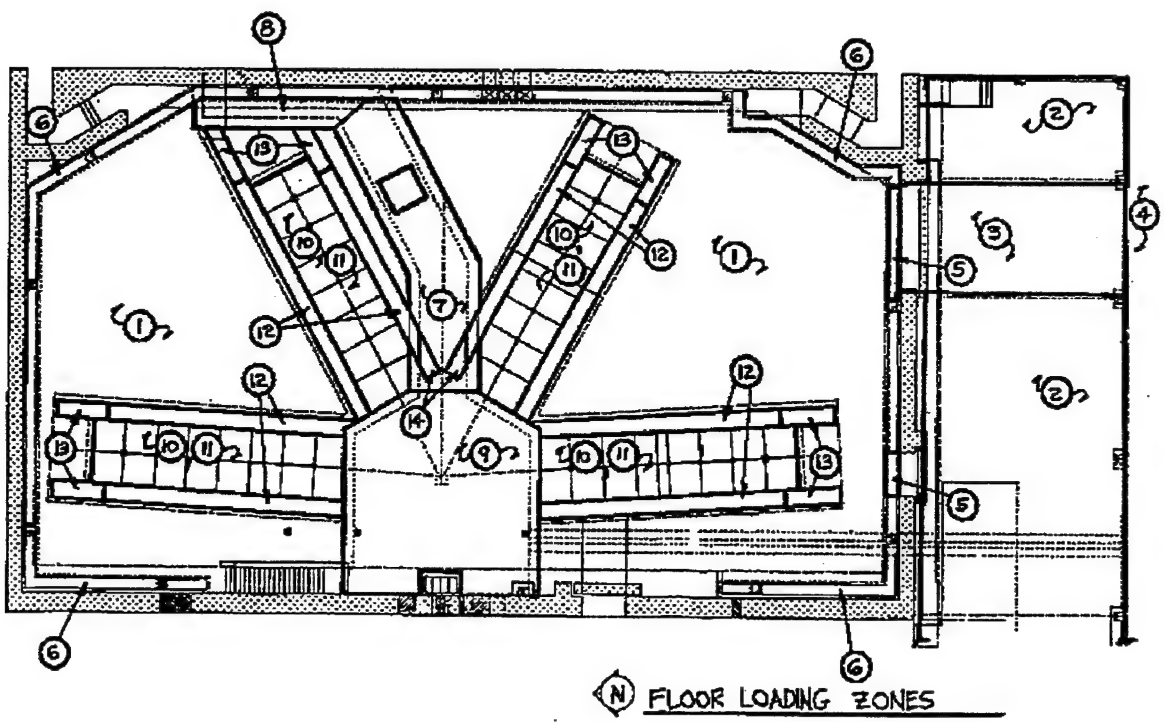



**Figure 4-1. Independent Structural Loading Map**

#### 4.1.4.1 Independent Structural Loading Analyses

During the preparation for the Simulator Mobility System CDR, PPI generated some specific floor loading data that had not been available previously. By this time, LAN was no longer available to assess the adequacy of their test cell floor design. The available design required floors withstand 2000 PSF distributed loads, but did not provide capabilities for handling concentrated point loads. To generate these data, H&N

## Table 4-2. DECADE X-Ray Simulator Facility Load Analysis

Holmes & Narver, 2/10/95

| Building Zone | Uniform Load: Allowable Load lbs/ft2 | Uniform Load: Safety Factor | Concentrated Load on 12"x12" contact area: Allowable Load lbs | Concentrated Load on 12"x12" contact area: Safety Factor | Truck Load HS 20-44 Note 1 | Forklift Load 3-ton capacity Note 2 | Special Loads |
|---|---|---|---|---|---|---|---|
| 1. Test Cell slab on grade | 2350 | 2.0 | 47,000 | 2.0 | OK | OK | |
| 2. User's shop slab on grade | 1100 | 2.0 | NA | | OK | OK | |
| 3. User's shop strengthened slab on grade | 2350 | 2.0 | 47,000 | 2.0 | OK | OK | |
| 4. Exterior concrete paving | NA | | NA | | OK | OK | |
| 5. Concrete trench cover | 2350 | 1.7 | 18,000 | 1.7 | OK | OK | |
| 6. Grating trench cover | 660 | 1.7 | 800 | 1.7 | NOT OK | NOT OK | |
| 7. Tunnel ceiling | 2000 | 1.7 | 140,000 | 1.7 | OK | OK | |
| 8. Tunnel ceiling at trench | 2000 | 1.7 | 26,000 | 1.7 | OK | OK | |
| 9. Basement ceiling | 800 | 1.7 | 53,000 | 1.7 | OK | OK | Note 3 |
| 10. Mobility trench steel grating, steel framing | 1500 | 1.7 | 8,000 | 1.7 | NOT OK | OK | Note 3 |
| 11. Mobility trench concrete floor | 2000 | 2.0 | 93,000 | 2.0 | OK | OK | |
| 12. Mobility trench concrete rail beams | NA | | NA | | OK | OK | Note 4 |
| 13. Mobility trench concrete rail beams within 10 feet of back end of beam | NA | | NA | | OK | OK | Note 5 |
| 14. Mobility trench concrete rail beams over tunnel | NA | | NA | | OK | OK | Note 6 |

Note 1: HS20-44 is standard highway truck loading. Maximum axle load - 32,000 lbs. Maximum wheel load - 16,000 lbs.

Note 2: 3-ton capacity forklift. Maximum axle load - 15,750 lbs. Maximum wheel load - 7,850 lbs.

Note 3: Basement ceiling and mobility trench steel grating, steel framing are OK to support front carriage caster loads as follows: 2 front casters, 4,000 lbs each; 2 rear casters, 8,000 lbs each.

Note 4: Mobility trench concrete rail beams more than 10 ft from back end of beam are adequate for following allowable simulator caster loads with safety factor of 1.7: a. 5 loads of 120,000 lbs each spaced at 8 ft on center; OR b. 11 loads of 46,000 lbs each spaced at 3 ft on center. Loads a and b are separate loads, NOT concurrent.

Note 5: Mobility trench concrete rail beams within 10 ft of back end of beam are adequate for following allowable simulator caster loads with safety factor of 1.7: a. 5 loads of 87,000 lbs each spaced at 8 ft on center; OR b. 11 loads of 43,000 lbs each spaced at 3 ft on center. Loads a or b are separate loads, NOT concurrent.

Note 6: Mobility trench concrete rail beams over tunnel are adequate for a single allowable simulator caster load of 120,000 lbs with safety factor of 1.7.

conducted an independent structural loading analysis. Specific designs aspects H&N reviewed included those for the Simulator Quad thrust columns, the slab under the Shielded Enclosure, rail beams, trench grating, perimeter trench bridges, and the reduced thickness floor over the tunnel behind the Simulator Quad 2.

ITT and H&N made several recommendations to address structural design shortfalls discovered during these analyses. Addressing these shortfalls early reduced operating and maintenance costs and mitigated the requirement for potentially costly future repairs. Some specific recommendations made by ITT and H&N are included in Table 4-1. Figure 4-1 shows the structural loading map for the Test Cell with associated notes shown in Table 4-2.

Shortly after the test cell was completed, on-site inspection discovered several cracks in the test cell floor in the vicinity of the east end of the basement equipment room. Initial characterization by the building contractor was that these were the result of concrete curing and were not serious. To provide an independent analysis of these cracks, H&N sent one of their concrete experts to AEDC to investigate. His analysis supported the RNJ claims.

#### 4.1.4.2 X-Radiation Shielding Integrity Analysis

The primary purpose of the DECADE facility is to create x-ray environments for systems testing. The test cell is designed to contain this radiation and to protect people and systems outside of the test environment. ITT used its expertise in radiation modeling to conduct independent analyses of the test cell design to ensure that adequate safety factors are maintained. These analyses involved the roof, the walls, the main access doors, and several examples of intentional and unintentional holes in the walls. We repeated these analyses whenever we encountered changes between the as-built conditions and the design.

##### 4.1.4.2.1 Sky Shine

Radiation leaking through the roof of the test cell would not normally be a concern since the direct propagation distance even to relatively low flying aircraft would cause the radiation intensity to fall off. However, since some radiation can be reflected back to the ground from the air (a phenomenum called "skyshine"), we needed to assess the roof design.

ITT used a one-dimensional transport code to calculate the radiation exposure levels to personnel in the areas surrounding the Test Cell. This approach modeled the air above the facility to consist of 1-dimensional slabs in which the incident fluence continues to fall off as $1/r^2$ from the source and attenuated by the concrete ceiling. The radiation code ANISN was used to calculate the attenuation through the concrete and the "backscatter coefficients" from the slabs of air above the roof. These slabs of air were then considered to be a plane source of uniform strength that were irradiating downward. Two types of shadowing were considered in the geometry. The test cell walls shielded part of the sky

from the source and also shielded personnel outside the Test Cell from parts of the irradiated sky. These calculations were performed for roof thickness of 10, 15, 25, and 30 inches. To meet the maximum per shot dose allowable, a roof thickness of 18 inches was required. As a direct result of these calculations, the thickness of the roof was reduced. Savings in the construction costs of the facility resulted directly from the reduction in concrete in the roof and indirectly, and more substantially, from reductions in the required thicknesses of the ceiling support beams and the perimeter support walls of the Test Cell.

Since the roof does not contain all of the radiation created in the test cell, we also recognized the need to limit access to the roof during testing. In designing the SSS, ITT incorporated techniques for monitoring the roof and providing positive controls to limit access to that area. This strategy was accepted by the state of Tennessee.

#### 4.1.4.2.2 Test Cell Radiation Shield Wall

During the building design activity, ITT worked with LAN to incorporate all available radiation data and protection requirements into the test cell design. After test data from DM1 was analyzed, we noted that the end point energy had increased from 1.5MeV (the data available during LAN's design) to 1.8MeV. This raised a question as to the adequacy of the radiation shield wall to provide protection to personnel in the UDAS screen room. ITT attempted to answer this question by using a SATURN 1.8 MeV spectrum as input to CEPX1LD radiation transport code to determine the dose behind the radiation shield wall as a function of density of the concrete. The geometry of the problem used in the CEPX1LD model included 22 ft of air and 45 inches of concrete wall with densities ranging from 1.87 to 2.232 gm/cm$^2$ for the concrete. The ratios of the atomic constituents of the concrete used in the model were not changed in the runs, only the density parameter was changed.

The radiation exposure limit for a single shot from DECADE is 277 microRem, as determined from the yearly exposure limit of 100 mRem/yr for pregnant women and teenagers and the specification of 360 shots/year. Radiation at DECADE is produced by two sources in the simulator, the output of the diode and the plasma opening switches (POSs). In the past, radiation shielding calculations have assumed the endpoint energy of the POSs to be 2.5 MeV as a worst case condition. With only the attenuation of the switch housings in their paths, the exposure level from the POSs alone was calculated to be 150 microRem. Using the most recent measured values for the concrete density, our models predicted the contribution from the 1.8 MeV diode spectrum was about 105 microRem, for a total of 255 microRem/shot. While this calculation verified the adequacy of the shielding design, ITT engineers (realizing the imprecision of the CEPX1LD code) recommended that operational procedures be developed, and documented in the radiation licensing requests, for continual monitoring of accumulated dose during DECADE operations.

#### 4.1.4.2.3 Test Cell Radiation Shield Doors

Three of the main access doors to the test cell are protected using large shield doors manufactured by Atomic Industries. ITT provided independent analysis of the designs for these doors to ensure that they did not violate the shielding integrity of the test cell. Calculations performed by ITT determined the x-ray fluence and total dose per shot at each door. In order to convert the fluences to dose tissue, the CEPX1LD code was used to determine the conversion factors for each of the photon spectra from the Bremsstrahlung diode (1.5MeV end point) and from the POSs (2.5MeV end point). The calculated total dose from those sources were 85.6 and 31 rads (tissue), respectively. In order to reduce these to the acceptable radiation safety level of 277 mirorads per shot the doors had to reduce the radiation by factors of 3091 and 1121 respectively. The west test cell door (the most stressing environment of the three doors) required about 15 inch thickness of Leadite with a density of 4.805 $gm/cm^3$ in order to meet the minimum attenuation requirement. For this analysis, atomic would not provide the atomic weight percentages of the leadite composition. ITT, therefore, had to estimate these percentages. Based on our calculations, the Atomic design provided adequate shielding.

We also questioned the design of the portal for the west door and recommended a design modification to decrease the probability of scatter beneath the door. Atomic Industries rejected our recommendation but agreed to warranty the door. They agreed to modify the door in the future if monitoring measurement indicate leakage under the door.

#### 4.1.4.2.4 Holes-In-The-Wall

Several radiation shielding integrity analyses were performed to assess the effects of holes in the front (west) wall of the test cell. These holes resulted from the removal of the support forms used when the wall was poured, or were intentionally built for access to the control rooms.

During the construction of the DECADE test cell, RNJ used support rods to support the concrete forms. These rods were removable after the concrete dried. ITT originally recommended the holes remaining after the rods were removed be back filled with high density grout in order to preserve the radiation shielding integrity of the walls. It was discovered that the grout used was only 84% as dense as the concrete poured in the walls. Site personnel were considering requiring that all of the holes (more than 1,000) be reworked. ITT performed several analyses to determine the effects of the less dense grout. After analyzing the geometry of the diode placement and the orientation of the holes, ITT determined that only the hole nearest the center line of the simulator diode would allow significant leakage and recommended that RNJ remove six inches of grout from the inside of the test cell in only that hole. A four inch long lead plug was placed in the hole and filled with two inches of grout to secure the plug and permit finish surfacing of the wall. This study resulted in considerable time savings to the program.

In addition to these holes, there were three large diameter holes designed into the radiation shield wall. These holes were intended to provided optical line of sight access for

radiation diagnostics to the diode from the UDAS and machine control rooms. To prevent radiation leakage through these holes, the original LAN design provided for a stepped concrete plug to be placed in each hole when it was not being used. Operational difficulties predicted for this design required a modification. AEDC engineers provided designs of simpler plugs that would prevent streaming and ITT analyzed their radiation shielding effectiveness from the distributed diode surface. The analysis of the final AEDC plug design indicated that it was successful in preventing streaming and provided adequate radiation shielding effectiveness. This design and analysis allowed the use of removable plugs should line of sight to the diode area for radiation diagnostics ever be needed.

Finally, three holes pass through the test cell wall just below the level of the test platform to permit the passage of signal cables to the User Data Acquisition System. ITT performed 1-D and 3-D analyses of the shielding design of the cable trays passing through these holes to determine whether a radiation hazard would exist in the shielded enclosure or in the tunnel beneath it. Our analysis verified that the lead-lined steel cable trays, and the cable bundles, would provide a level of shielding at least as effective as the concrete. We noted, however, that the geometry of the full DECADE Bremsstrahlung diode might result in a slightly elevated radiation level in the tunnel near the center trough. While this level should still be below safety requirements, we recommended a conservative approach to monitoring accumulated radiation dose in that region. We also suggested use of lead bricks to further shield that region if needed.

#### 4.1.4.3 RF Radiation Shielding Analysis

ITT conducted an analysis of the effectiveness of the steel-reinforced concrete test cell walls in containing radio-frequency emissions from the Simulator. This analysis, coupled with another analysis of the ringing of the Test Cell, led ITT to the conclusion that DSWA could rely on the natural attenuation of the Test Cell walls for RF radiation containment without taking additional steps to create a Faraday cage. This recommendation included not tying the wall rebar electrically to the roof to avoid unwanted energy containment in the test cell. We also illustrated the importance of the electrical integrity of the rebar, resulting in the CoE looking more closely at, and ultimately approving, the exothermic welding process proposed by RNJ.

### 4.1.5 Life Cycle Analysis

#### 4.1.5.1 Remote ICC Analysis

ITT performed a preliminary cost/benefit analysis of the proposed DECADE RICC system. The rough estimate of cost for this modification (the "Remote ICC") was $1.8M above the Latest Revised Estimate for the planned ICC. A careful analysis of the advantages and disadvantages of the RICC was required to justify such a significantly increased expenditure of DSWA funds.

ITT performed the trade study and the results are as follows. As compared to the ICC, we found that the RICC would offer the following five advantages:

- reduced operations labor

- reduced simulator maintenance
- improved simulator performance
- improved shot rates
- support for future simulator upgrades

Our rough estimate of cost/benefits associated with the RICC suggest that estimated costs could be recouped in as little as six years entirely from savings in labor costs. Avoidance costs associated with damage to major simulator components or to the test items constitute a potential offset of much greater (but as yet undetermined) magnitude. Increased user costs for repeat testing or test delays could represent cost growths on the order of 10% or more for each user, significantly impacting the user acceptance of DECADE. Finally, costs associated with future ICC capability enhancements potentially offset the anticipated remote ICC costs. Some of these enhancements are currently viewed as essential by many potential users.

After reviewing ITT's report, DSWA decided to proceed with the RICC up-grade. The decision was widely accepted by the community as an important enhancement for the DECADE machine. Our trade study provided value to DSWA by providing quantitative estimates of the time needed to recoup their financial investment.

4.1.5.2 Nitrogen Venting Hazard/Life Cycle Cost Study

AEDC requested a design modification to install an automated liquid nitrogen supply system. Their rationale was two-fold: to decrease the hazards associated with large volumes of liquid nitrogen in the test cell and to decrease the operational costs for manually replenishing cryogens. Their proposal identified the conversion and venting of 200 gallons (in four 50-gallon dewars) of LN2/GN2 into the Test Cell as a potential personnel hazard. To mitigate this hazard, they proposed installation of piping to handle the LN2 flow into the Test Cell (i.e., an automatic LN2 delivery system with storage tank out of doors), at significant cost to DSWA.

To evaluate this proposal, ITT analyzed the hazards introduced by utilizing nitrogen from dewars *vs.* piping and came to the following conclusions:

Only in a worst case scenario (simultaneous catastrophic rupture of all four LN2 tanks) would a potential nitrogen hazard (O2 depletion) exist. To combat this unlikely event, we recommended installing O2 deficiency sensors and alarms, especially in the basement area.

Under normal DECADE operation, LN2/GN2 release rates will not equal the refresh rates of the two air handling units servicing the Test Cell; there will be only a negligible rise in the N2 concentration of air within the Test Cell. ITT concluded that installation of ducting dedicated to venting expended LN2/GN2 from the Test Cell was not warranted. ITT did, however, recommend that DECADE facility operating plans ensure that air handling systems are operating during machine operation and/or when LN2 is present within the test cell. ITT also recommended health check circuitry for O2 deficiency sensors.

Absent the safety concerns, ITT analyzed the savings in operational costs versus the acquisition costs for the automated system and concluded that life-cycle savings in operational labor would not recoup system installation costs during the projected life of the system.

### 4.1.6 Reliability And Maintainability Analyses

ITT assisted DSWA in ensuring that the DECADE test facility incorporated reliability and maintainability in its design. Because of the evolving nature of many portions of the DECADE design, ITT did not perform numerical (*i.e.*, quantitative) assessment often associated with classical reliability, availability, and maintainability (RAM) analyses. Instead, ITT (assisted by our A&E subcontractor H&N) ensured reliability and maintainability were incorporated in DECADE's design and construction by conducting independent reviews of DECADE subsystem designs. Our recommendations were often the result of cost/benefit trade studies and recognized the fact that DSWA had limited MILCON funding available. ITT and H&N made recommendations to DSWA on improving designs and the use of pedigreed/tested components and construction techniques. These recommendations were focused on producing a DECADE facility with a minimum of downtime for maintenance, and between test series. By minimizing the likelihood of failure and facilitating easy test setup, ITT helped DECADE's design ensure high facility availability.

### 4.1.7 Safety Analysis

Ensuring safety of personnel and equipment has been a key goal for the DECADE facility from the first concept design. DSWA assigned ITT the role of monitoring all aspects of facility safety. Our role included many activities addressing safety issues: we established and chaired the Systems Safety Working Group (SSWG) to develop a systems outlook on safety, to establish the applicable formats and monitor the generation of systems safety documentation, and to ensure resolution of safety concerns. The unique safety issues associated with construction and operation of a test facility based on routine and reliable operation of high voltage equipment to generate hostile levels of ionizing radiation make safety analysis a high priority undertaking. This section addresses some of the examples of safety analyses.

#### 4.1.7.1 Tennessee Radiation License

ITT developed the initial draft of the radiation license application submitted to the state of Tennessee. As integrator, ITT was best positioned to address the facility level issues related to safe operation of the radiation sources. Although the ultimate responsibility for safe operation will rest with the simulator operator (PPI, transitioning to AEDC), ITT was in the best position to address the unique interaction of the simulator operation and the hazard mitigation provided by the building and SSS designs. Preparation of the license application comprised review of all applicable State, AEDC Base, and Federal regulations, assessment and documentation of the adequacy of the building for providing radiation-shielding, description of potential/expected radiation leaks and mitigating

countermeasures, and drafting of the license application. ITT met with the licensing officials in Nashville and established the initial definition of State regulatory requirements concerning DECADE. Included in the application were many of the analyses of shielding integrity of the test cell, design of the shielding doors, and design considerations for the access control system and facility operational procedures. After drafting the application and coordinating its content with the State officials, ITT passed responsibility for final submission to PPI, with overview by the ITWG (which superseded the SSWG).

4.1.7.2 System Safety Hazard Assessments (SSHAs)

ITT and our A&E subcontractor H&N developed draft SSHAs for the DECADE Building, Support Building, Shielded Enclosure, and Safety and Security System. ITT also instituted the approach for an overall DECADE facility SSHA draft which identifies the hazards associated with the operational facility. The responsibility for completing the facility SSHA has been accepted by the AEDC facility operations team, with ITT assisting.

In preparing these drafts, ITT used the format developed and used by AEDC for its other test facilities. Figure 4-2 illustrates the SSHA format and the specific analysis drafted to describe the absence of a Halon fire retardation system in the shielded enclosure. The SSHAs consider hazards to personnel, equipment, test unit downtime, data compromise, and the environment. Furthermore, each hazard category is broken down by level of severity and assigned a likelihood of occurrence. The right-hand side of Figure 4-2 identifies the risk probability codes (RPC), a consequence of the severity of the event and its likelihood of occurrence. RPCs of 2 and below require either waivers or approvals by the AEDC base safety office before operation of the facility, or fixes mitigating either the likelihood or severity of the adverse event must be instituted.

**SYSTEM SAFETY HAZARD ANALYSIS AND RISK ASSESSMENT** | SYSTEM/CONFIGURATION ITEM NUMBER | SUBSYSTEM NUMBER | PAGE 7 OF 12

**TITLE: DECADE SHIELDED ENCLOSURE MECHANICAL**
SUBSYSTEM HAZARD ANALYSIS

PROJECT NUMBER | DATE | SSHA NO.

BRIEF DESCRIPTION (PORTION OF TEST/PROJECT/OPERATION/SYSTEM COVERED BY THIS ANALYSIS):
Sprinkler System (lack of)

ANALYSIS IS (Check one)
☒ INITIAL ☐ REVISION ☐ ADDENDUM

PROBABILITY INTERVAL 20 Years

*DECADE SYSTEM SAFETY*

**REMARKS** Designers were concerned about false alarms triggering sprinkler system and dousing the UDAS instrumentation, in addition to potential breaks in electrical isolation. As a result, there is no fire protection sprinkler system in the Shielded Enclosure.

| HAZARD DESCRIPTION | CAUSE | EFFECTS | TARGET | RISK ASSESSMENT WITH EXISTING COUNTER-MEASURES SEV | PROB | RPC | EXISTING COUNTERMEASURES AND/OR RECOMMENDATIONS TO LOWER RISK INCLUDING ESTIMATED COMPLETION DATE. | RISK ASSESSMENT AFTER RECOMMEN-DATIONS SEV | PROB | RPC |
|---|---|---|---|---|---|---|---|---|---|---|
| Fire | Electrical malfunction/short | Personnel injury, equipment damage, downtime. | P | II | D | 3 | **EXISTING COUNTERMEASURES**<br>Fire detection system shuts down power to the Shielded Enclosure and activates alarms.<br>One-hour-rated fire wall surrounds Shielded Enclosure.<br>Fire department in close proximity to DECADE.<br>**RECOMMENDATIONS**<br>Install Halon fire suppression system replacement/ equivalent when available.<br>[Halon is ozone-depleting substance.]<br>HAZARD STATUS<br>ESTIMATED COMPLETION DATE | II | E | 3 |
| | | | E | I | D | 2 | | I | E | 3 |
| | | | DT | II | D | 3 | | II | E | 3 |

**TARGETS: P - PERSONNEL E - EQUIPMENT DT - DOWNTIME DC - DATA V - ENVIRONMENTAL I - INTERFACE**

| PREPARED BY | DATE | APPROVED BY AEDC SAFETY EVALUATOR | DATE | APPROVED BY DNA | DATE |
|---|---|---|---|---|---|
| Kaman Sciences Corp. | 1 February 1996 | | | | |

**Figure 4-2. SSHA Example**

ITT and H&N prepared drafts for the elements mentioned above by analyzing designs for structural, architectural, mechanical, and electrical hazards. Once identified, the hazards were standardized in the AEDC format and mitigation approaches recommended (if any). ITT then forwarded these draft assessments to AEDC's safety office for comment and review. AEDC safety personnel reviewed the hazards to ensure compliance with building and OSHA codes and consistency with other AEDC facility SSHAs. ITT iterated with AEDC on potential fixes to ensure compliance with applicable codes and AEDC operating procedures.

### 4.1.7.3 Fire Safety of Shielded Area Access Control Doors

When the SSS installation plans developed sufficiently, it was realized that the RF shield doors were incompatible with typical access control devices. The ITWG considered options, and AEDC pushed for secondary hollow metal doors. This work-around provided the required functionality, but fire safety was raised as an issue. The problem was that entrances to the UDAS Shielded Enclosure room and to the "baby SCIF" were on opposite sides of the corridor and that the doors open toward each other. Fire codes require emergency egress paths be a certain minimum dimension, after having accounted for open doors. H&N reviewed applicable codes and provided a design consistent with

the regulations. This analysis precluded the possibility of a more expensive, future retrofit.

4.1.7.4 Beryllium Activation Study

One hazard that was postulated related to the eventual use of the simulator to assess the survivability of space optics subsystems incorporating mirrors constructed from beryllium. This material, because of its low atomic weight, provides advantages due to its low x-ray absorption cross section. The hazard that was postulated was that x-rays at the high end of the DECADE energy spectrum might cause activation of the beryllium, leaving it in a radioactive state, requiring special safety procedures for handling and storage. Such handling procedures were not specifically designed into the DECADE facility. ITT analyzed the probability of radioactive isotope formation resulting from radiation of beryllium and reported that, for the x-ray energies produced by the DECADE simulator, no significant risk existed. In completing this analysis, ITT also investigated cross sections for activation of all other materials likely to be tested at DECADE and for the range of x-ray energies to be produced. Our report concluded that no hazard exists requiring facility modification or planning for special material handling. In the event that radioactive materials are brought to the facility (for example, radioactive cobalt for use as a radiation source), appropriate handling procedures will be needed and will be developed by facility and AEDC base safety personnel.

4.1.7.5 Safety Analysis of Phoenix Operations at DECADE

In 1997, ITT performed an analysis of the safety aspects of operation of a fast x-ray generator, like or derived from Phoenix, in the DECADE test cell. This is one of several considerations for expanding the capability of the facility to provide multispectral test environments. Since the end point energy of the Phoenix Bremsstralung spectrum (approximately 4 MeV) exceeds the design specification of the DECADE radiation sources (2.2 MeV), the safety considerations for operation required some analysis. The penetration of radiation through the shield wall is directly related to the end point energy of the photon spectrum.

Our reported study results established a table of allowable operating conditions for the fast x-ray apparatus as shown in the following table (from our report):

**PHOENIX ALLOWABLE RADIATION LEVELS**

| MATERIALS | ATTENUATION FACTOR ($X10^3$) | RAD LEVEL AT WALL (rads) | OUTPUT SPHERICAL* (krads) | OUTPUT COLLIMATED** (krads) |
|---|---|---|---|---|
| Concrete | 22.7 | 3.6 | 1.2 | 1.5 |
| Concrete + 1" Pb | 58.7 | 9.4 | 3.0 | 3.8 |
| Concrete + 2" Pb | 185 | 29.6 | 9.5 | 11.9 |
| Concrete + 3" Pb | 585 | 93.5 | 30.3 | 37.9 |

* Also applies for Machine centerline normal to wall with $1/r^2$ fall off

** Machine centerline at 22 degrees

We also calculated the maximum weight of a three-inch lead shield (<4 tons) so that operational impacts of that alternative could be assessed.

### 4.1.8 Quantitative Risk Analysis

ITT, in concert with DSWA, identified the need to conduct systematic, DECADE-wide *quantitative* risk assessments (QRA) and accompanying risk mitigation plans. Previous risk assessments had been non-systematic and too focused in scope. The *gut feel* approach to risk assessment did not do a good job of isolating high-risk components of DECADE.

To better identify, understand, prioritize, and commit resources to reduce the risks associated with the DECADE development effort, ITT developed an approach to provide a quantitative risk assessment for the DECADE facility development project. ITT developed a QRA that covered the facility construction period through DECADE initial operational capability (IOC).

#### 4.1.8.1 Methodology

ITT employed the QRA approach described in Air Force Materiel Command Pamphlet 63-101, dated 15 September 1993. The Air Force methodology decomposes risk assessment into analyses of risk probability factors (see Table 4-3) and risk consequence factors (see Table 4-4). Using this methodology, a risk analyst assesses the probability of an adverse event occurring in each of six areas (requirements, technology, management, engineering, manufacturing, and support) and multiplies these probabilities by risk consequence factors for performance, schedule, and cost, respectively. The analyst then sums these products to develop an overall quantitative risk assessment score. Depending on the level of assessment required, this analysis was performed for system components, subcomponents, or piece parts, as necessary. This approach attempts to address all elements equally, mitigating the subjectivity associated with many risk assessments.

The risk analyst ranks the results of the probability/consequence analysis from highest to lowest composite risk score. This ranking permits the program management staff to establish meaningful risk-based priorities for issue resolution, and identifies areas in which

risk mitigation strategies should be developed for those components of the program with highest risk scores.

**Table 4-3. Risk Probability Factors (Source: Air Force Pamphlet 63-101)**

| REQUIREMENTS | |
|---|---|
| • Fully defined, no instability due to threat or user uncertainty. | 0.01 |
| • Few secondary areas still need definition, broad threat data needed for design. | 0.3 |
| • Multiple users (different use environments) moderate detail needed. Several areas undefined (none critical). | 0.5 |
| • One-three critical areas undefined/ill-defined. | 0.7 |
| • Critical requirements ill-defined or unachievable. Detailed threat information needed for successful design. | 0.9 |

| TECHNOLOGY | |
|---|---|
| • Operational and deployed. | 0.01 |
| • In use, another program (not past IOT&E). | 0.2 |
| • Technology transition experiments successfully completed. | 0.5 |
| • Initial proof-of-concept experiments successfully completed. | 0.7 |
| • Basic research only. No development work. | 0.9 |

| MANAGEMENT | |
|---|---|
| • All needed resources (skills, personnel, processes, facilities, tools) available in-house; demonstrated management talent for project of this magnitude. | 0.01 |
| • Minor resource limitation. | 0.2 |
| • Limited experience on project of this magnitude. | 0.3 |
| • Key resource limited, or must be developed/major upgrade. | 0.5 |
| • Major resource limitations, no management experience. | 0.7 |
| • Lacking critical resources. | 0.9 |

| ENGINEERING | |
|---|---|
| • Qualified item which meets all requirements. | 0.01 |
| • Existing item which requires qualification. | 0.1 |
| • Existing item requiring minor modification. | 0.2 |
| • Existing item requiring major modification. | 0.4 |
| • New design, can be done with existing parts or software modules. | 0.5 |
| • New design (new parts, software). | 0.7 |
| • New design, requiring state-of-the-art advance. | 0.9 |

| MANUFACTURING | |
|---|---|
| • Existing processes meet yield, tolerance, and throughput. Facilities, vendor base available (proof tested). | 0.01 |
| • Upgrade of existing processes, facilities, or vendors to meet requirements. | 0.2 |
| • Minor capacity limitations, or limited availability of vendor materials. | 0.3 |
| • Moderate capacity/vendor limitations, or significant upgrades to process/facilities required. | 0.5 |
| • New manufacturing process–within state-of-the-art. Major facility or vendor capacity limitation. | 0.7 |
| • New manufacturing process needed–state-of-the-art advance; critical facility or vendor not available. | 0.9 |
| **Facility** includes all physical plant, tooling, and personnel needed to manufacture system. | |
| **Vendor** includes all sources for elements of the system not built by contractor. | |

| SUPPORT | |
|---|---|
| • Support resources defined and available (people, data, equipment, spares). R&M meets/exceeds requirements. | 0.01 |
| • Support requirements defined and resources being finalized. Resources apparently available. | 0.2 |
| • Minor resource shortfalls, or secondary deficiencies in R&M. | 0.3 |
| • Moderate resource shortfalls. | 0.5 |
| • Support resources not fully defined; R&M significantly below requirements. | 0.7 |
| • Support resource needs unknown; logistics characteristics (*e.g.*, failure mode, repair process) unknown. Critical support resource not available. | 0.9 |

**Table 4-4. Risk Consequence Factors (Source: Air Force Pamphlet 63-101)**

| PERFORMANCE | | SCHEDULE | |
|---|---|---|---|
| • No effect on element or system performance (includes producibility and support). | 0 | • No effect on element or system schedule. | 0 |
| • Potential degradation of element performance, but system level not affected. | 1 | • Increase in element schedule but system schedule unaffected (slack available). | 1 |
| • Degradation of element performance, minor decrease in system performance (still above requirement). | 3 | • Increase in element schedule affects ability to meet intermediate milestone. System schedule has slack. | 3 |
| • Degradation of element performance, moderate decrease in system performance (requirement still achieved). | 5 | • Minor increase to system schedule (<10%). | 5 |
| • Decrease to system performance eliminates all margin. | 7 | • Moderate increase to system schedule (<40%). | 7 |
| • System requirement not achieved (25 if requirement designated critical). | 10 | • Major increase to system schedule (>40%). | 10 |

| COST | |
|---|---|
| • No effect on cost. | 0 |
| • Element cost increase <10% (against planned/allocated costs). | 3 |
| • Element cost increase <25%. | 5 |
| • Element cost increase <50%. | 7 |
| • Element cost increase >50%. | 10 |

4.1.8.2 Implementation For DECADE

ITT developed a quantitative risk assessment technique for DECADE based on the approach discussed above. We developed risk assessments for each of DECADE's major components as identified in the DECADE Interface Control Document (Figure 4-3). ITT also added a category specifically for systems integration. Issues associated with

integration are broader than the System Engineering and Integration contract held by ITT; integration was defined to include installation at AEDC, testing and acceptance, and configuration management.

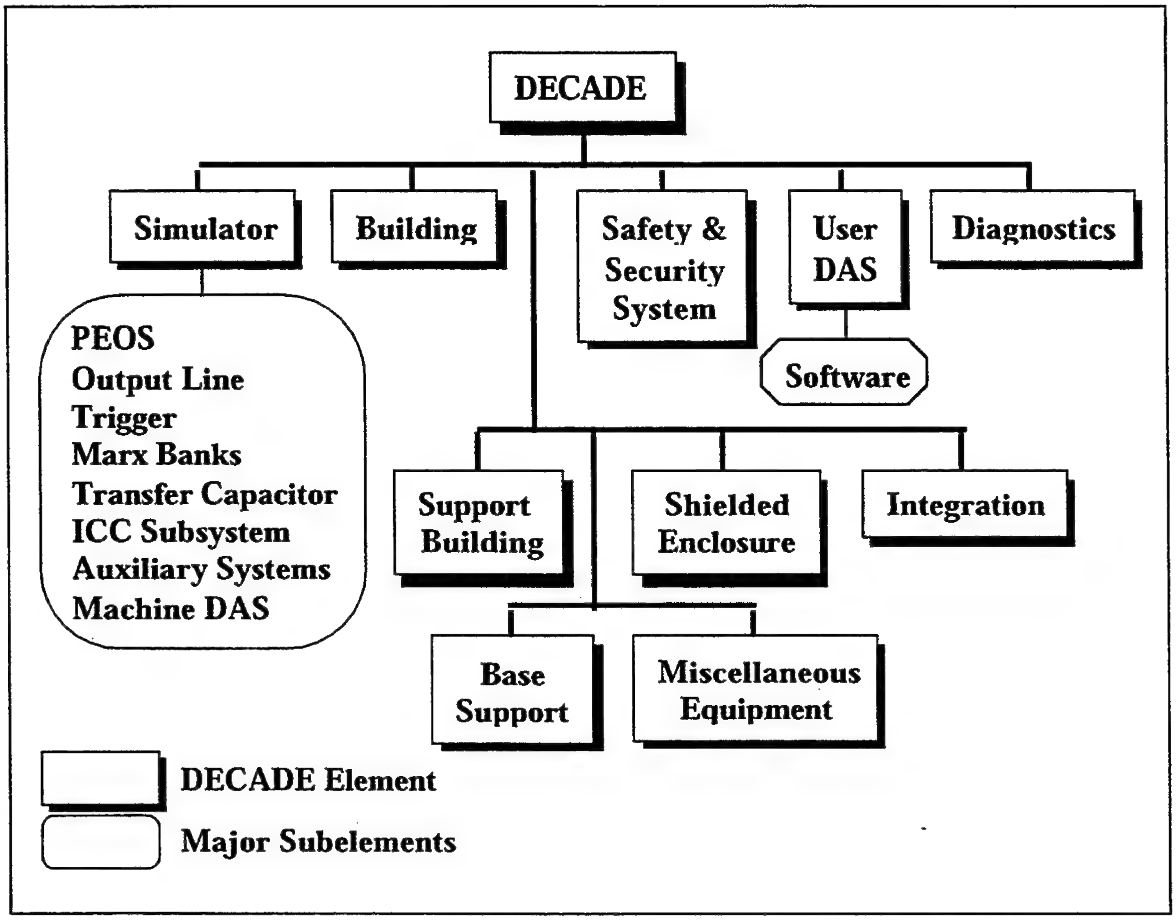



**Figure 4-3. DECADE Quantitative Risk Assessments**

To better identify and quantify the risks associated with DECADE, ITT further developed risk assessments for subcomponents of high risk items: the simulator and user data acquisition system.

These QRAs quantified the risk to reach IOC. ITT did not include post-IOC considerations in this risk analysis.

The requirements risk probability factor considers the maturity of requirements definition for DECADE components and services. The technology risk factor addresses the status of the technology incorporated into DECADE. The management risk factor deals with the management organization, personnel, and procedures of the parties comprising the entire DECADE facility development team. Engineering considers the ability of the community to *design* DECADE components. The manufacturing risk factor addresses the ability to

manufacture according to the engineering design, within predetermined tolerances. Manufacturing also considers capacity and second source issues. The support risk probability factor addresses sparing strategies, maintenance and repair, and logistics.

The performance, schedule, and cost risk consequence factors are described in Table 4-4. For this exercise, ITT baselined the schedule and cost data from the time of the initial assessment (November 1994) to IOC in August 1996 (~ 2 years) and estimated cost to complete (~$50M). Therefore, 10% adverse schedule and cost impacts would be approximately 2 months and $5M respectively. We have identified other assumptions on each risk evaluation worksheet. A sample risk evaluation worksheet is shown in Figure 4-4.

Component: Simulator
ICD#: 1.0

| Requirements | | | Technology | | | Management | | |
|---|---|---|---|---|---|---|---|---|
| Prob 0.3 | P | 6 | Prob 0.6 | P | 10 | Prob 0.6 | P | 7 |
| | C | 5 | | C | 3 | | C | 5 |
| | S | 7 | | S | 7 | | S | 7 |
| Subtotal: | | 5.4 | Subtotal: | | 12 | Subtotal: | | 11.4 |
| **Engineering** | | | **Manufacturing** | | | **Support** | | |
| Prob 0.8 | P | 10 | Prob 0.8 | P | 10 | Prob 0.6 | P | 3 |
| | C | 5 | | C | 5 | | C | 1 |
| | S | 7 | | S | 7 | | S | 4 |
| Subtotal: | | 17.6 | Subtotal: | | 17.6 | Subtotal: | | 4.8 |

| | |
|---|---|
| Performance: | 29.8 |
| Cost: | 14.9 |
| Schedule: | 24.1 |
| Total Score: | 68.8 |

Issues:
- Pulse forming line technology.
- Test chamber window definition, technology.
- Cost/schedule management.
- Vendor capacities.
- Ability to meet R&M not demonstrated.
- Machine alignment.
- Front end design not complete.

Assumptions:
- Output requirement 8 kRad.
- Pulse width, 45 ns.
- Uniform (2:1) area, 10,000 cm2
- Compatibility with existing building.
- SAB is part of DECADE P3I.

**Figure 4-4. Example Quantitative Risk Assessment Form**

ITT arbitrarily assigned red risk flags to each item with a composite risk score of 20 and above, yellow to risk scores between 10 and 20, and green for scores below 10. We proposed writing risk mitigation plans for those components of DECADE with yellow and red risk flags. Where possible, ITT drafted the mitigation plans (*e.g.*, Integration). However, in many cases, these mitigation plans had to be written by the most cognizant organization (*e.g.*, PPI for the simulator). ITT, as the system integrator, coordinated the development and review of these mitigation plans. A sample risk mitigation plan is shown in Figure 4-5.

| Risk Component: Integration (top level) | |
|---|---|
| **Issues** | **Assumptions** |
| - Adequate PMO staff<br>- Roles, responsibilities, and authority not defined<br>- Timely, accurate schedule info needed<br>- Not all critical interfaces necessarily defined<br>- Test & acceptance requirements not fully defined | - Impacts measured in ability to meet IOC<br>- Integration defined to include entire facility<br>- Revised CM Plan & Control Document in place |
| **Mitigation Strategy** | |
| PMO Staff: DSWA is using and empowering the ITT system engineering and integration staff to perform many tasks which were previously the responsibility of the DECADE PMO.<br>Schedule: An integrated DECADE schedule has been in place for approximately one year. The DECADE PMO has recently given increased emphasis to scheduling activity, providing stronger PMO support in the collection of schedule data from all DECADE Program participants. ITT, using a dedicated staff member for scheduling, has implemented a computer-based master schedule for all major components of DECADE. This schedule is updated each month. ITT and the PMO use the scheduling tool to identify critical path components and those components near the critical path and track resources. DSWA management has stressed the importance of timely schedule input to DECADE component organizations.<br>Interface Control: ITT has developed a configuration management plan. The DECADE PMO is placing greater emphasis on the ICD and using an interface assessment to focus attention on interface issues.<br>Configuration Management: The DECADE PMO and ITT have developed a DECADE Configuration Management and Control Document to freeze and document DECADE's design. DSWA has established stringent guidelines for making changes to the baselined designs.<br>Test & Acceptance: DSWA has directed ITT to develop a DECADE Test and Acceptance Plan. | |

**Figure 4-5. Sample DECADE risk mitigation plan (dated November 1994)**

ITT prepared/updated risk assessments prior to each DECADE Project Management Review (PMR). These assessments were available for DECADE PMO use in briefing the status of the program at each PMR, comparing the current DECADE risk assessment

with the assessment completed for the PMR two months prior. For those components of DECADE in which risk scores changed substantially from one assessment to the next, ITT identified the factors that led to the changes.

The ITT-developed QRA process gave DSWA a practical means of objectively assessing and tracking DECADE risk. It also served as an effective tool in communicating DECADE risk to higher DSWA management. DECADE PMO personnel and DSWA management used the DECADE QRA as a tool to assist in budgeting management reserve to reduce program risk. However, without DSWA management support (resources and authority), and accurate and timely input from DECADE contractor and government organizations, ITT will be unable to provide high-confidence risk assessments.

### 4.1.9 Quality Assurance/TQM

ITT worked with DSWA to maintain an aggressive Total Quality Management and Quality Assurance (TQM/QA) program for the DECADE program. Some of the basic factors involved in a TQM/QA program are depicted in Table 4-5.

**Table 4-5. Basic TQM/QA Factors**

| |
|---|
| Identifying problems |
| Analyzing the problems |
| Developing potential solutions |
| Selecting a solution |
| Implementing the solution |
| Plans for continuous improvements |

We were a staunch supporter of the DSWA/AEDC "Partnering" Program. One means of implementing "Partnering" was through the various working groups that were established for integration of the elements into the DECADE facility. ITT personnel chaired or occupied key positions at these meetings to assist DSWA in implementing partnering in all aspects of the DECADE program. The most effective forum for partnering interactions was the Integration and Test Working Group (ITWG). Typical topics at these meetings included status of the elements, planned installations, review of test plans and reports, work in process, technical integration issues, etc. Frequently side meetings were called to discuss and resolve various integration/installation issues. These meetings provided excellent opportunities for exercising "Partnering" between the participants to resolve schedule conflicts, interference between work areas, delivery of items, or other such integration issues. All of the items in Table 4-5 at one time or another were implemented during these meetings.

ITT's participation in these meetings was a major factor in assuring TQM/QA throughout the DECADE program. We either chaired or acted as executive secretary for these meetings and provided DSWA written meeting reports, documenting the events that

transpired. We provided onsite personnel to work the day-to-day integration issues and provided DSWA with a direct oversight capability. Members of the DSWA DECADE PMO have indicated that ITT onsite support was invaluable in assuring proper construction/integration of the elements. This oversight process helped verify that the items being installed conformed to the as-built configurations and that any modifications were properly documented. In addition, all information was reported to DSWA and DSWA personnel notified immediately of any critical issues that could not be resolved onsite or during the integration meetings.

ITT personnel provided general oversight for all aspects of the DECADE program to ensure DSWA received delivery of a top notch X-ray simulation facility. Many of the technical obstacles to simulator performance adversely impacted this goal, but we tried to ensure that no issue within our purview would undermine ultimate facility performance. During the acceptance process, ITT developed various checklists to verify critical interfaces between the elements and proper functioning of critical systems. This verification process was another function that our onsite personnel performed during the on-going TQM/QA process.

## 4.2 PROGRAM MANAGEMENT SUPPORT

### 4.2.1 Administrative Support

A key aspect of the ITT team's integration support role was the facilitation of meetings to communicate requirements and status reporting. ITT has been extremely active in this role by: hosting meetings in its facilities; providing administrative support for meetings; and attending and participating in a wide variety of meetings. ITT plays a major role in recording, preparing, and distributing meeting agendas, minutes, and reports. ITT has actively participated in the majority of the meetings held in support of the project. This support was done in conjunction with our effort to be the official DECADE information repository.

The Alexandria office of ITT provided the DECADE program the flexibility and continual administrative and technical support to hold any size meeting. ITT utilized it's three large secure conference rooms, each capable of holding approximately 70 people, for numerous DECADE program meetings. Several small conference rooms were also utilized for non-classified DECADE meetings. Each conference room was equipped with white boards and vugraph projectors. Meetings, including SSEB deliberations, building design reviews, PMRs, ITWGs, and TAG meetings, have been held at ITT. Our Alexandria office was utilized due to its central location between two large airports, multitude of accommodations available for out of town participants, and the close proximity of the office to DSWA Headquarters. This ability to offer the PMO a central meeting location complete with professional support and equipment, provided added flexibility in arranging and holding project meetings.

ITT utilized a state-of-the-art on screen projection system called "LightPro" and laptop computer to provide polished and professional briefings. The use of Microsoft

PowerPoint Slide Show provided on-line color briefing capabilities. ITT hosted several meetings where the LightPro was used with scheduling software SuperProject and Microsoft Project to brief DSWA management. This provided an ability to perform on-line analysis and proved an effective tool to conduct "what if" analyses during the meeting with instant results.

Additionally, ITT developed briefing materials for our use and for the Program Management Office. On several occasions, ITT participated in the preparation of briefings and materials for PMO presentations to the DSWA Director and Government Agencies.

ITT participated in meetings as a representative of the PMO, when requested. This provided the PMO the flexibility to focus limited resources in areas of critical concern, while still maintaining control and involvement in all aspects of the program. ITT representatives actively participated in or conducted various meetings where their focus was to serve in the interests of the PMO. For example, the ITT on-site representative , conducted weekly integration meetings as a representative of the PMO. ITT engineers represented the PMO at various technical meetings dealing with simulator development, and at various design reviews, requirements definition meetings, specification development meetings, etc.

ITT hosted and supported a large number of DECADE meetings serving in various roles. ITT provided both administrative and technical support on the DECADE project. Support was continuous throughout execution of the program. A listing of these meetings can be found in Appendix A of this report.

As the Systems Integration contractor, it was vital that ITT both received and disseminated information in a fast and effective manner. This meant active participation in numerous and various types of DECADE meetings, reviews, and briefings. These meetings were both formal and informal. The following sections outline ITT's role in supporting the integration of the DECADE facility through timely and effective participation at all levels of the program.

#### 4.2.1.1 RFP Preparation/SSEB Support

ITT supported the Source Selection Evaluation Board for the DECADE radiation source contractor. ITT was responsible for hosting the SSEB which lasted approximately four weeks. During this time frame, ITT played a vital role in providing the logistics and administrative needs of this effort. Meeting facilities for evaluation board members was provided in our Alexandria, Virginia office. It was ITT's responsibility to secure all competition sensitive material during the SSEB. ITT was able to secure this material by utilizing secure conference rooms and strong rooms. Administrative and secretarial support was provided for the duration of the SSEB. This included the compilation of all bidders scores and the typing and distribution of comments to offerors.

#### 4.2.1.2 System Safety Working Group (SSWG) Meetings

ITT played a key role in ensuring system safety for the overall facility. Primary efforts were focused on facility wide hazards, safety training, System Safety Hazard Analysis and radiation licensing application. This effort required coordination with other DECADE element organizations. ITT facilitated this required coordination and transfer of technical information by supporting formation of and chairing the System Safety Working Group (SSWG). The SSWG met to discuss matters regarding safety for the facility and its associated systems. This included identification of technical problems and design deficiencies as they impacted safety. ITT reviewed PPI's designs for simulator hardware and installation fixtures and procedures to ensure proper safety requirements were addressed. We reviewed their recommended countermeasures and provided them our comments on content and completeness. As the documentation of systems safety hazards approached closure, the activities of the SSWG were incorporated into the functions performed by the ITWG. A record of SSWG meetings can be found among those listed in Appendix A, ITT Supported Meetings.

#### 4.2.1.3 Building Design Reviews

Two different concepts were being evaluated for simulator design. These concepts were so different that one building design would not satisfy the needs of both. Because of time constraints, the building design was needed prior to a simulator decision. Meetings to review progress in the two building designs were held in parallel, protecting the confidentiality of each simulator concept from the other potential source contractor. Design reviews were held at both ITT and the A&E facilities. Meetings centered on review of design, exchange of information, and the resolution of any identified issues or conflicts. ITT's role was to foster group communication and provide a systems integration-level review to ensure all requirements had been addressed in design and to ensure compatibility between simulator and building design.

#### 4.2.1.4 Building Working Group Meetings

Subsequent to the selection of the building contractor, a Building Working Group (BWG) was established to address construction issues. The BWG met monthly for about 10 months and discussed problems, changes, schedule issues. ITT gathered insights into impacts of changes, found out when changes had to become official, reviewed construction options with AEDC and CE, and kept track of contingency funds to support resolution. The BWG functions were gradually incorporated into the weekly building teleconference described in the next paragraph and community-wide issue review and resolution were incorporated into the Integration and Test Working Group.

#### 4.2.1.5 Weekly Building Teleconferences/Integration Issues

Weekly building teleconferences were established as a means for all project team members to keep abreast of all the activities concerning the design and construction of the main DECADE facility. The fluidity of these issues favored more frequent and less formal communications than what was provided through the BWG. The weekly teleconferences

gave the PMO more opportunity for direct involvement than on-site meetings or formal monthly reviews. They also provided a forum for other off-site interests, for example, the PPI engineering staff. ITT prepared the agendas for these teleconferences and assisted the PM in keeping meetings focused on actions to resolve outstanding issues. These teleconferences provided the linkage to on-site activities discussed in the next paragraph.

#### 4.2.1.6 Weekly On-site Building Coordination Meeting

ITT participated in weekly status meetings held by the COE. These meetings involved the construction contractor (RNJ), all of its on-site subcontractors, personnel from the COE, and AEDC DECADE personnel. ITT utilized these meetings to resolve time dependent integration issues associated with the DECADE facility. The number of required work-arounds increased as other system elements began installation into the uncompleted building. Critical problems arose that would result in schedule slips and cost increases if work-arounds were not identified. ITT used these meetings as a vehicle for identifying and proposing work-around alternatives, and as the integrator, to maintain control of onsite changes, ECPs, and other schedule and resource conflicts. At each meeting a building status update was provided for the main building and support building. Scheduled work for the following week was also discussed. Each element then provided an update on their progress. Any conflicts or problems arising from this status update were then addressed and resolutions were determined. ITT was an active participant in this process.

#### 4.2.1.7 Instrumentation and Diagnostics Working Group (IDWG)

During the early design period, the PMO established the IDWG to ensure that the full community could establish a set of coordinated requirements for UDAS and MDAS sensors. The IDWG met only for a short period, addressed the needs of the user community for specific measurements, and went inactive when most of its recommendations were incorporated into the RICC or the UDAS. The long delay in completing simulator design and in installing the simulator systems into the facility made continued concern about test instrumentation premature. As efforts to bring the facility on line increase, ITT recommends that the issues still outstanding from the IDWG be readdressed. We documented this recommendation in a memo to the PMO in early 1997.

#### 4.2.1.8 Integration And Test Working Groups (ITWGs)

The Integrated Test Working Group (ITWG) meetings evolved as a result of the maturation of system designs. As the building construction was nearing completion, the emphasis of the project team became the integration and installation of the various other system elements in the building. The ITWG was established as a formal meeting to ensure communication among all the players was established. As the systems integrator on the DECADE program, ITT chaired the meetings and developed the agendas. Representative from each of the subsystem elements comprise the remaining members of the group. The main participants are represented in the Table 4-6.

Meetings were held monthly with the majority of them taking place on-site at AEDC. The format of the meetings remained fairly consistent with the DECADE Program Manager briefing general program issues. Each subsystem program manager then provided a status report for their element which included past performance, tasks for the following month, a status review of assigned action items, and discussions on critical issues.

ITT utilized the meeting to facilitate discussion on the Integrated Master Schedule. The critical path and major element changes were presented and discussed. Scheduling conflicts were identified and then the ITWG used the time as a means for mitigating identified schedule risks and developing required work-arounds. ITT presented resource assessments to highlight plans the system elements had for occupying building areas and to ensure conflicts got resolved so no one's installation was negatively impacted. ITT finished with a rolling wave assessment designed to highlight upcoming activity resource requirements over the next six months.

**Table 4-6. ITWG Participants**

| Subsystem | Organization |
|---|---|
| DECADE PM | DSWA/EST |
| Systems Integrator | ITT |
| Building | US Army Corps of Engineers |
| Simulator | Physics International |
| Shielded Enclosure | NISE East Norfolk Det |
| UDAS | SvT |
| Safety and Security System | NISE East Charleston |
| Technical Support | SvT |
| AEDC Base Engineers | AEDC Personnel |
| Field Support | DSWA Field Command |
| Program Support | Logicon/ RDA |

ITT utilized the meeting to present the status of the configuration control actions and the status of the Interface Control Document. Critical interfaces were highlighted and the ITWG solved issues identified for specific interfaces and/or to assign action items for resolution of interface problems. This ensured interface design issues were raised to the appropriate level so that corrective action would be taken.

ITT was also responsible for the transition and acceptance activities of the main building, support building, and each system element. ITT presented status briefings on each of these activities, and included discussions on acceptance testing and verification activities. ITT utilized the ITWG as a forum for progressively planning and coordinating acceptance testing and verification activities.

ITT used the ITWG meetings to facilitate discussions on assigned action items that were not addressed at any other time in the meeting. Response to actions were clarified and assignment of new actions accomplished. ITT took responsibility for distributing meeting minutes and an updated action item list to all participants after the meeting. The meeting notes and charts were then filed in the DECADE data repository for historical purposes.

ITT used the day after the ITWG as a time for inspection of the building and discussions on integration details with each system element. These small meetings were used to work the minute details of integration issues. This time was also used to have one on one meetings to discuss design deficiencies and installation problems and their resolutions. ITT established this informal day of meetings to foster open communication in a non-confrontational manner so that successful results could be achieved.

In July 1994, the Integration and Test Working Group incorporated all the other working groups. From then on, main technical information exchange took place at the ITWGs. If a topic warranted a special meeting, then a separate one was arranged and all involved parties invited to attend. This was done to eliminate duplication of meetings and minimize the amount of travel required, saving program costs. A listing of all the Integration and Test Working Group meetings can be found in Appendix A under ITT Meeting Support Listing.

#### 4.2.1.9 Program Management Reviews (PMRs)

PMRs were initiated early on in the program as high level reviews for DSWA upper management. The first meeting was held at AEDC on October 8, 1991. These meeting were held monthly or bimonthly at various locations with ITT hosting a total of three PMRs. The key participants in the PMRs are the same as those shown for the ITWG in Table 4-6, with the addition of members of the DSWA upper management who attended on occasion.

The PMR provided a setting to discuss the status of each program element. The DECADE Program manager briefed the status of the overall program. Each element program manager then briefed their status in the same manner. This provided a way to inform all DECADE participants of the status of the complete program and served as a forum where formal action items could be assigned to resolve problems which could not be solved at a lower level.

ITT participated in the PMRs both administratively and technically. ITT coordinated and distributed meeting agendas, minutes and action items. ITT contacted each element prior to the meeting to determine critical issues which warranted representation. These issues were then prioritized and placed on the agenda. The minutes of the meeting were taken

and distributed by ITT. Any action items originating in the meeting were also recorded and managed by ITT. This was done through the use of Action Item Input Information Forms and the Automated Action Item Database. ITT also provided programmatic and technical support to the PMO during these reviews. ITT participated, technically, in the PMRs as the systems integrator. In this capacity, it was ITT's responsibility to monitor any potential changes to any systems such that the standards, specifications and function of that or any other system was not impacted. ITT provided an independent analysis and overview to DSWA so that the PMO would have a clear picture of the issues being presented as input in critical decisions. A complete listing of all PMRs can be found in Appendix A under the ITT Meeting Support Listing.

#### 4.2.1.10 Technical Advisory Group

The Technical Advisory Group (TAG) consisted of a group of experts from the pulse power community brought together initially for technical advice and counsel to the PMO pertaining to ongoing efforts in specification development, feasibility studies, development planning, proposal evaluation, data review, and other DECADE related activities. This group provided support to DSWA when required and or requested. The choice of TAG members selected for particular topics depended on their specific technical expertise. ITT participated on the TAG on some issues and supported its activities on all issues.

- During the simulator procurement deliberations, the TAG advised the SSEB on various technical issues. ITT participated on the Management Structure assessment team.
- After selection of PPI, the TAG advised the PMO on diagnostic instrumentation and simulator controls. ITT participated in reviews and formulation of recommendations. We also help document system requirements and specifications, including the need for the automated remote instrument command and control system.
- The TAG evaluated the recommendation to provide a grounding scheme that would allow isolation of the simulator and data collection systems from the building. ITT performed independent calculations of the grounding designs that were included in the TAG recommendations to allow this design modification.
- The TAG reviewed all test results generated at PPI. ITT participated in these reviews, either providing independent data analysis or validating analyses provided by other TAG members. ITT helped develop the electrical models used to describe opening switch operation. ITT provided independent validation of the combinatorial procedures used by PPI to generalize single module performance to that of the full DECADE simulator. Exceptions to PPI techniques were included in several memoranda to DSWA and PPI and resulted in procedural modifications.
- The TAG administered programs to improve DECADE performance ("remediation") and to investigate alternative switch/MITL designs ("switch assessment"). ITT

participated in these programs primarily in an administrative function, providing scheduling and meeting support.

- The TAG reviewed the SNL magnetically contained POS design for adaptation to DECADE. ITT participated on that study, participated in several reviews of the MCPOS design both at DSWA and at SNL in Albuquerque and co-authored the recommendation to DSWA to continue with MCPOS development in a parallel track of the switch assessment effort. In general, we supported the general TAG technical opinion that no major design issues were apparent in MCPOS, although the conversion of MCPOS from the smaller TESLA machine to the larger DECADE, and the required change in polarity of the switch, might cause unforeseen performance problems; technical risk was moderate. Cost risk was judged slight, at a programmed cost of $3-5 million extra for the DECADE program. Schedule risk was also considered slight, but higher than cost risk, because of some perceived management problems, which resulted in an unclear priority for the DECADE effort at SNL.
- In early 1996, the priority for testing at lower x-ray wavelengths than could be created with the Bremsstrahlung source seemed to be increasing at the Army Strategic Systems Development Command. This caused DSWA management to reassess the importance of the plasma radiation source (PRS) for DECADE. DSWA held two meetings at PPI (April and August, 1996) to allow the technical community to discuss the feasibility of implementing PRS on a single DECADE Quad. ITT participated in these meetings. The outcome of the April meeting was a clear need for a definition of the criteria for PRS performance. DSWA asked ITT to participate in the formulation of a criteria document for the PRS. The committee to generate this document consisted of Dr. Ihor Vitkovitsky (RDA Logicon), Dr. Bob Commisso (NRL), Dr. John Abruzese (NRL), Mr. Robert Almassy (ITT), Dr. Ralph Schneider (DSWA) and Major Jed Rowley (DSWA). This committee meet several times at NRL (May, June, and July 1996) and generated the criteria document which was subsequently approved by DSWA and presented at the August PPI meeting. The criteria document became the basis for a research effort begun in the Fall of 1996 to design and build a PRS front-end for the DECADE Quad. This program is still progressing as this report is being written.

#### 4.2.1.11 Weekly PMO Staff Meetings

Until the building was completed and the simulator development stalled, ITT participated in routine weekly PMO staff meetings usually held at DSWA. On a few occasions we hosted the staff meetings. These meetings allowed all of the DSWA staff members (including contracts, civil engineering, and programs) to have access to program status information. ITT participated to gather information on all aspects of the program, report our progress, point out issues, and make recommendations for resolution. We routinely reported master schedule issues. We also compiled the weekly report to DSWA management, first to satisfy the requirements on the PMO levied by Col Yelmgren, and then to keep for the PMO records as specified by the PM.

#### 4.2.1.12 CTEIP Proposal Support

DSWA and AEDC initiated the development of a Consolidated Test and Evaluation Investment Program (CTEIP) Proposal in the spring of 1996. The formal proposal was ultimately submitted to OSD in January 1998. ITT assisted with the development in a variety of ways. Our primary objective was to ensure that Systems Engineering and Integration received the proper emphasis. If DSWA and AEDC are successful in adding radiation sources and the other capabilities included in the CTEIP proposal, there will be many system engineering issues.

ITT supported many meetings where the CTEIP proposal was worked on by the community. Because of all the politics with the proposal, it was often very difficult to overcome the "negative energy" surrounding these discussions. ITT tried to keep the group focussed on those aspects which could be controlled. Our involvement helped the community progress from the early draft stages to the final submission.

### 4.2.2 Integrated Master Schedule

As the systems integrator, ITT was responsible for ensuring the smooth integration of all elements and for making sure all required resources were available to satisfy planned element schedule needs. ITT developed the Integrated Master Schedule as a management tool for accomplishing the planning, monitoring, and reporting of programmatic and technical progress. The integrated Master Schedule consisted of a top to middle level hierarchy of task information from each major element in the program. This schedule was used to track and report progress; to identify schedule resource conflicts; and as a basis for developing work-around plans necessary to avoid program schedule slips and cost overruns.

#### 4.2.2.1 Element Schedules

ITT worked closely with each element in the development of its schedules, and used that information to build and maintain the integrated master schedule. Early on in simulator development, ITT assisted Physics International in developing a realistic schedule which was in tune with all other aspects of the program. In concert with an advisor from the Defense Systems Management College, ITT participated in several meetings held at PPI to develop the schedule and associated task interdependencies. ITT coordinated with PPI to identify work-arounds which would minimize the impact to the schedule. ITT then worked with PPI to incorporate the work-arounds into the schedule, identifying any required interdependencies and or new tasks. Similar scheduling support was given to AEDC SvT during development and maintenance of the User DAS schedule.

#### 4.2.2.2 Interdependencies

The Integrated Master Schedule is a model for program performance. It describes the development processes for each element and shows how the execution of each step in the process affects completion of the element. To do this accurately, each step is analyzed to determine its resource requirements (principally for DECADE, its duration) and how it depends on previous steps or impacts succeeding steps (its "dependencies"). It includes

not only the dependencies within each element, but also those between the various program elements (the system "interdependencies"). It was the responsibility of the individual program managers to identify dependencies within their element. ITT took responsibility for identifying interdependencies between all elements.

With this model in place, ITT could predict the effect of schedule slips in any element on the overall program For example, the Shielded Enclosure had to be completed before the installation of cables and equipment for the User DAS (an "interdependency"). A slip in the development schedule of the Shielded Enclosure caused a predictable slip in the UDAS development schedule. This type of tracking information was critical to plan where resources should be expended to decrease the risk of meeting a planned Initial Operational Capability (IOC) for the facility. As these types of issues arose, ITT took the lead in developing and implementing mitigation plans in order to minimize the impacts on the overall program. For this particular example, ITT took the lead in identifying where UDAS schedule slack existed and pointed to these areas where time could be saved. After reviewing the UDAS/building interdependencies, ITT also assisted the UDAS team in identifying alternative locations for equipment build-up and initial testing, to mitigate the effects of building schedule slip on the UDAS completion date.

Another example of using the schedule to identify and mitigate risks centered on the delivery of simulator parts and their dependency on the completion of Test Cell crane. ITT used the schedule to identify that the crane would not be available to support the off-loading of the simulator parts. The test cell crane was installed but not accepted. ITT made sure the necessary steps were taken to ensure RNJ, the building prime contractor, would be available to operate the crane as needed. ITT's knowledge of planned parts deliveries facilitated the success of this work-around.

As the program evolved, and redirection occurred, the schedule was updated to reflect the changes. New activities were identified, such as the switch assessment program, and the new tasks were incorporated either into the Integrated Master Schedule or maintained as separate schedules. ITT developed the interdependencies between existing tasks and milestones, and these new activities, so that their impact to program-level milestones and objectives could be tracked and reported

#### 4.2.2.3 Schedule Standardization

Each month, ITT collected the latest schedule information from each of the program elements. The information was submitted to ITT in various forms. Some elements used software packages, some kept schedules manually, and some, not at all. Because this information lacked a standard format, ITT was forced to enter it manually into Super Project, our computerized scheduling tool. As the schedule became more complex, this became increasingly cumbersome and time consuming. In order to eliminate this problem, ITT persuaded the community to adopt Microsoft Project (MP) as the standard scheduling tool. All elements began to use MP and from that point all schedule information was submitted electronically through the DECADE Bulletin Board in MSP format. ITT merged the files into one program to establish the interdependencies among

the various elements. The standardization of data collection reduced the amount of time for data entry in half, and allowed for a quicker turn-around of an up-dated schedule for PMO use.

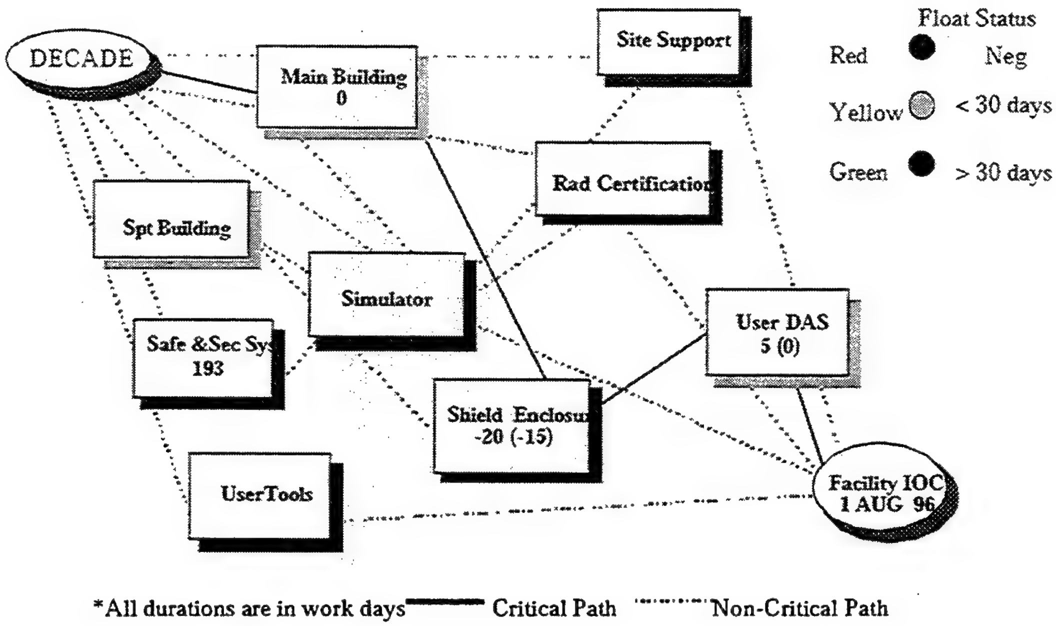



**Figure 4-6. DECADE CPM Network (27 June 1995)**

4.2.2.4 Schedule Distribution

ITT distributed schedule information at the monthly ITWG meetings. A Critical Path Method (CPM) chart (Figure 4-6) and GANTT charts at various levels of detail were used to illustrate schedule changes and issues. The CPM chart was used as a top level view of the overall program. Total float was shown for each element, and the critical path to IOC was also highlighted. ITT implemented a color code assignment scheme to highlight the amount of slack each element had before impacting the critical path. Red was used to designate negative float, yellow for zero float, and green to show the element had more than 30 days of float before impacting the critical path.

ITT maintained an overall program schedule and often presented critical schedule information at PMRs and ITWGs in the form of GANTT charts, as shown in Appendix B, to illustrate the major activities of each element. We maintained our DECADE schedule database in Microsoft Project, which gave us great flexibility to open and close tasks and to vary time scales to allow us to focus attention on the pertinent schedule issues during any presentation. Interdependencies and interference with critical resources (space, personnel, support equipment, etc.) between each of the elements were also illustrated. ITT utilized this chart to show each element which external activities were impacting their program and how their reported progress was impacting other elements. ITT updated the schedule data as needed and presented the GANTT chart on a monthly basis. Each month, ITT prepared schedule update charts for each element as an organized way to present all changes from the previous month. Each chart listed the task activities' status,

slack, dependencies, impacts, and planned work-arounds for the previous month, and facilitated discussion on what had been completed or how planning had changed it. Revised and new work-arounds were developed to mitigate any newly identified risk or issues.

ITT discussion of schedule changes and impacts at the ITWG meetings provided an efficient means for garnering input concerning all risks and impacts from the program community at large. The method proved to be a timely and effective way of resolving schedule problems. Each element was made aware of overall program status, and how identified issues were effecting their system. Problems which were identified but could not be completely mitigated on-site, could be taken back to respective companies for further analysis and resolution.

ITT used a "rolling wave" method as a means of identifying planned future activities. All schedule activities planned for the next six months were analyzed. The six month duration was broken into three, two month periods. All schedule activities planned to occur in the 0-2 month window were evaluated by ITT for potential slips, impacts or conflicts. ITT analyzed all tasks in the 3-4 month window from a the top level to identify potential slips. Finally, ITT evaluated all tasks in the 5-6 month window to identify any areas of future concern. This rolling wave analysis was presented, monthly at the ITWG. It provided awareness to all element PMs as to any issues associated with their near term activities, and a "heads-up" on potential future issues, so that work-around development could begin and be readily tracked prior to the issue affecting schedule or cost.

#### 4.2.2.5 Quantitative Risk Assessments

The Integrated Master Schedule was used in assessing the schedule risk associated with each element as a part of the Quantitative Risk Assessment performed by ITT. The progress of each element and its relationship to the program critical path were considered in determining a risk value. The use of the schedule provided a quick, easy, and accurate way of completing assessments for the individual elements. These assessments allowed the PMO to see where critical schedule attention was needed.

### 4.2.3 Program Manager's Handbook

During the early stages of the program, the PM needed ready access to a broad selection of program information. ITT worked with the PM to design and create the Program Manager's handbook to fill these needs. The Handbook included historical data, information on each element, schedules, CCB data, a calendar of events, phone numbers, Action Items, Memoranda of Agreement between various program participants, etc. ITT updated this handbook regularly, providing information on all aspects of the technical and financial planning and on the status of the DECADE program.

## 4.3 TECHNICAL LIAISON AND COORDINATION SUPPORT

### 4.3.1 Information Transfer

#### 4.3.1.1 Automated Action Item Database

Using the commercial database management software package, RBASE, ITT developed a data storage architecture for generating, recording, and tracking action items related to the

| PMO/ITT S&SC |
|---|
| A.I.# ________ |

DECADE ACTION ITEM
INFORMATION FORM

| **ACTION ITEM ORIGINATOR** | |
|---|---|
| SUBJECT: | DATE: |
| DESCRIPTION: | |
| ORIGINATOR NAME/ORGANIZATION: | |
| SUGGESTED SUSPENSE: | |
| SUGGESTED RESPONDENT: | |

| **PMO/ITT S&SC** | |
|---|---|
| DSWA POC: | OFFICIAL SUSPENSE: |
| OFFICIAL RESPONDENT: | |

**Figure 4-7. Action Item Form**

DECADE facility. This tool was loaded on a personal computer and maintained by ITT. The database contained all action items dealing with the DECADE program. Special committees meetings action items were also incorporated into the database.

Action Items were assigned where there was a need for more information, a work-around plan, or any issue where information must be distributed from one element to another. The action items provided a way to remind everyone of their responsibilities. As action items were generated, an action item form Figure 4-7 was filled out with the following information: a brief description, the originator, the responsible party, the DSWA oversight person, the required engineering specialty, reference documents, resolution

documents, and the suspense dates. This information was then entered into the system and a number was assigned to it.

An action item was closed after the responsible party had submitted a written response to the item originator. Once the originator had agree with the resolution and had been reviewed by the PMO, the suspense data was removed and the action was denoted in the database as being closed. The information was entered into the database for historical references. The use of the database provided a manageable way to track the action items that occurred.

| ***AI#*** | ***Item*** | ***ORIGINATOR*** | ***RESPONDENT*** | ***SUSPENSE*** |
|---|---|---|---|---|
| 1084 | Evaluate redistributing the HF/LF/VLF digitizers from one GPPIB to two (UDAS PDR). | SNL; R. Aden | AEDC | 03/14/97 |
| 1287 | Perform load test on equipment lift. | ITT | AEDC | 03/14/97 |
| 1393 | Based on availability requirements for a DECADE quad, perform a cost/benefit analysis on the currently designed MITL positioning system (ITWG). | C. Myers | PPI | 05/30/97 |
| 1395 | Complete and/or obtain as-built documentation for the UDCN, CNSC and EMCS (ITWG). | ITT; G. Maples | AEDC | 03/14/97 |
| 1396 | Perform sample testing of UDCN wiring and CNSC fiber (ITWG). | C. Myers | AEDC | 03/14/97 |
| 1401 | Evaluate options for calibrating UDAS digitizers and provide cost estimates (ITWG). | C. Myers | FCDSWA | 03/14/97 |
| 1408 | Document and distribute the test approach/plan for the "top-level UDAS requirements demonstration" that is scheduled to follow system check-out (ITWG). | ITT; S. Stafford | AEDC | 03/07/97 |

**Figure 4-8. Sample Action Item Listing**

An updated listing was distributed at the monthly ITWG meetings and at the PMRs. The open action items list was reviewed at all pertinent meeting and teleconferences to update everyone on their status. A print out of the action items was done by exporting the information into a Microsoft Word file. This provides a simple way to generate action item status reports in an electronic file format. This file was then distributed through the use of E-mail and the BBS. A partial printout from the database can be found in Figure 4-8.

The database was also used as a reference source to find documents on a prior issue. Key words were entered and a search was done to retrieve reference topics. The database was designed such that it can be sorted by any category. This provided a flexible way to retrieve information on a topic. When each action item was closed there was some form of written documentation to close out the item. This document was entered in the database as key references. The ability to find documents on a subject in a efficient manner was very useful and utilized numerous times.

#### 4.3.1.2 Bulletin Board Access

ITT utilized the combination of a Bulletin Board and Electronic Mail to maintain communications due to the wide geographic dispersion of organizations supporting the DECADE PMO. This tool permitted the PMO to generate fully coordinated documents, and transmit the information in an expedient manner to all program participants without relying on telephone conversations and conventional mail messages. The centralized bulletin board system operated on a PC with a 1-800 number and was maintained by ITT at our Alexandria, Virginia Office. This system utilized a software package called Wildcat which provided a secure architecture to control access to DECADE information. A total of 51 people had access to the DECADE BBS at any given time.

Each person authorized to use the system was given an account and a security level. The security level of the person depended on the level of involvement in the program. The various security levels provided privacy within the DECADE community. Table 4-7 shows the eight different security levels.

**Table 4-7. Bulletin Board Access Hierarchy**

| | *Security Level* | *Authorized Personnel* | *Usage* |
|---|---|---|---|
| 1 | General Public Messages | All Bulletin Board Users | General messages and information on how to use the bulletin board |
| 2 | General DECADE Messages | All Bulletin Board Users | Meeting Schedules and Agendas |
| 3 | DECADE Private | DECADE Contractors | Contractor Communications |
| 4 | Government | Government Personnel | Government Communications |
| 5 | DECADE PMO | PMO Staff | Staff Communications |
| 6 | ITT Team | ITT Personnel | ITT Internal Communications |
| 7 | PM | Program Manager | Messages/Information to PM |
| | Systems Administration | 3 ITT Personnel | Maintenance |

A person with a security level had access to everything in that area and below. Therefore the DECADE PM could see everything in all six prior level. The ITT Team has access to everything below their level (6) and so on. Anyone can leave a message or upload a file to any level, but cannot read other information in that level if they are not authorized that security level.

The BBS allowed the transfer of binary files in the electronic form instantaneously. Once files were up loaded anyone with the security privilege can down load the files through the use of a modem. Files such as schedule information, CAD drawing, memos, action item lists, and other pertinent information were transferred through the BBS. The use of the BBS eliminated the wait time that it took to mail disks or hard copies. The transmission of files allowed the flexibility for CAD files, memos and other documents to be updated and revised on line without duplication of efforts.

The use of the BBS had come in handy for the design integration layout of the basement area for simulator equipment. Because of simulator design changes, the layout of equipment in the basement area had changed significantly. More equipment was add, such as the PA-80 for the vacuum system, had to be located within the already confined space. This caused a systems integration problem in space allocation in the basement. Due to the near completion of the building, most of the piping and electrical outlets were already installed according to the old building design. As a integration problem, ITT supported PPI in their efforts in re-designing this layout by providing as built data. This was done by taking physical measurements of the equipment installed in the basement per the original design. These as built dimensions and locations were then illustrated using

AUTOCAD software to determine layout and interface clearances. Once this layout was completed, it was transmitted via the BBS to PPI for distribution among their contractors and in-house engineers. The transfer of this file allowed PPI to incorporate the drawing into their CAD system.

Another example of the time effectiveness of using the BBS was through the submittal process of scheduling information. Each month PPI transmitted their program schedule through the BBS. This allowed the data contained in the schedule to be accurate up to the moment it was transferred. This information was then provided to the PMO. The shipping time for this information was reduce to a few seconds. This allowed the PMO to make accurate and precise decisions base on the most current and up to date information.

The BBS also contains general information for DECADE personnel to download on an as needed basis or to distribute general information. The action items list, DECADE Personnel Roaster and other information was updated periodically and place on the BBS for distribution. The BBS was backed up to tape roughly every two months. This provided an electronic back up of documents that had been distributed for future reference.

Earlier in the program the BBS was utilized much more, but the evolution of the E-mail has reduce the usage. E-mail is mostly used today, but the BBS serves as a way of transmitting large binary files that were difficult to transmit by encoding for the E-mail process. ITT had an internal connection that provide E-mail access. The E-mail capability had been a vital mode of communication to communicate with personnel on travel. This ability was every effective since most organizations are not co-located at AEDC.

4.3.1.3 Automated Personnel Address/Telephone Database

An automated Personnel Address/Telephone database was developed by ITT using RBASE. This database was used to support the identification of personnel associated with the DECADE program and to facilitate effective communications within the community. The database included the name, address, voice telephone numbers, facsimile numbers, overnight express mail addresses and electronic mail addresses of each associated person. The roster was updated regularly and was widely distributed to the DECADE community in both paper copies and in electronic form.

The use of the database for personal information provided a simple and effective way to manage the influxes of personnel coming and going on the program. Each DECADE participant utilized the printouts as a personal DECADE phone book. The use of the automated phone book provided an efficient manner in filing and maintaining personnel information in an organized manner.

# 5. SYSTEM TEST AND EVALUATION (T&E) SUPPORT

## 5.1 TEST PLANNING

ITT has aggressively pursued test planning with each DSWA executing agent and contractor selected for building and installing the elements. During each PMR, ITWG meeting, or other test-related meeting, ITT has discussed issues associated with testing the element, and with element performance once integrated into the DECADE Facility. We have made extensive use of the Interface Control Document to alert element contractors of testing required to ensure proper integration of their element with the rest of the facility.

### 5.1.1 ITWG Coordination

The main forum for coordinating testing issues has been the ITWG. Generally a status of each element's progress was provided at the ITWG. Any issues arising from the ITWG presentations were handled either at subsequent side meetings or by assignment of action items. Results of either approach were reported to the ITWG. In addition, ITWG members with appropriate expertise typically reviewed the test plans/reports for the elements or their subsystems and provided approval/disapproval recommendations. ITT, as chair of the ITWG, coordinated this process to make sure that testing issues were satisfactorily handled. In this manner, the ITWG membership was kept apprised of testing requirements and progress.

The ITWG was also used to ensure adequate feedback between the element contractors. Interface issues have been worked out between contractors before serious incompatibilities resulted. ITT on-site personnel were instrumental in providing guidance during the installation of the elements. If conflicting requirements arose between the installing contractors, ITT personnel held on-site meetings between the affected organizations to resolve the issues quickly. If a satisfactory resolution was not obtained, the situation was brought to the attention of the DECADE PMO for action.

### 5.1.2 Test Scheduling

Scheduling was an important part of the test process. From the beginning of the DECADE program, ITT kept a detailed schedule of DECADE events. Early in the development of an element, ITT gathered basic schedule information regarding testing. As installation approached, detailed schedules were required even to the level of day-to-day activities. ITT coordinated this scheduling effort with each element contractor. This detail was used not only to make sure that equipment arrived on time and could be accommodated, but also to avoid interference between the test personnel of one element with the installation workers of another element. ITT on-site personnel were able to use "Partnering" effectively to provide work-arounds, so each contractor could perform his required duties.

### 5.1.3 Test Support

Several months prior to any testing, contractors were to alert DSWA and AEDC as to what would be required to perform the test by submitting their test plan. During the ITWG meetings, ITT addressed the requirements for acceptance of each of the elements to alert the individuals involved to plan for testing of their systems. In addition, prior to the testing, on-site ITT personnel made sure that the proper resources were available for the test personnel. If they were not available at the DECADE facility, arrangements were made with AEDC to provide what was needed for the test.

Each of the DECADE element contracts contained requirements either for acceptance testing of the entire element or of its subsystems, with satisfactory completion of the testing and delivery of required data and reports leading to acceptance of the element. An overall facility integrated test was not a contractual requirement for any of the element contractors. The philosophy of ITT's approach to integrated systems testing required that we seek the smallest set of additional tests to supplement element acceptance testing and still achieve confidence in the operation of the integrated facility. This required that ITT be intimately involved in the definition and coordination of element test planning and execution. To this end, ITT developed several documents to provide guidance for integrated systems testing and to define an overall acceptance process.

- The *Management Plan for Acceptance of the DECADE Facility* was a ITT initiative that describes and implements the philosophy to be used for acceptance of the DECADE Facility and its elements.
- Deficiencies in the acceptance and testing process as applied to the building and support building elements highlighted evolutionary improvements needed in this plan, so improved transition plans were developed to facilitate acceptance of both those elements and the remaining elements to be incorporated in DECADE.
- An integrated systems testing document was also produced to identify any integrated systems testing that will be required when all the systems are integrated into the facility.

We describe these documents in the following sections.

## 5.2 MANAGEMENT PLAN FOR ACCEPTANCE OF THE DECADE FACILITY

To provide a coordinated plan for the acceptance of each of the DECADE elements and the overall facility, ITT developed the *Management Plan for Acceptance of the DECADE Facility.* The objective of the plan was to define the management approach that will be used to bring the DECADE Facility to Initial Operational Capability with the transition of operational responsibility from DSWA to AEDC. The document considers efficient utilization of government resources, quality, timeliness, and safety. Activities necessary to train a technical work force to operate facility equipment and to assure that associated supporting data analysis and process control software programs function correctly are also included. To achieve these goals, this management approach draws upon existing

AEDC operational skills and experience, develops requirements for AEDC staff buildup, and provides a smooth transition of the DECADE facility and personnel into normal AEDC operations.

The Management Plan was approved by DSWA and AEDC in November 1994 after ITT wrote and distributed several drafts and rewrites and briefed the plan at ITWG meetings held during the previous year. We sent copies to all members of the ITWG, including the element contractors. Even though the plan is not a contractual obligation, it provides the acceptance process that the element contractors should follow. The Plan has become the central management tool for control of the acceptance process at the DECADE facility. It documents application of an acceptance philosophy based on coordinated testing of all DECADE elements, with careful review and oversight by the ITWG to ensure validation of element performance and especially verification of element interfaces, such that acceptable confidence in full facility operation can be gained with little or no required testing of the full facility. Within the Management Plan are the definitions of required documentation, planning and testing processes, and work flow controls to satisfy the acceptance philosophy. ITT was charged with administering facility acceptance with the careful discipline needed to follow the procedures established in the Management Plan, a responsibility that will be transitioned to Field Command and AEDC following this contract.

## 5.3 TRANSITION PLANS

During the development of the Management Plan it became very apparent that modified acceptance plans were needed for the building and support building. This was because the Corps of Engineers acceptance process did not contain an overall test plan for either building. The only comprehensive document was the submittal register listing deliverables required by the specifications. There were individual tests and verifications for each specification, but there was not an overall acceptance process. ITT generated transition plans for the building and support building to fill this gap.

Final approval of the Building Transition Plan and Support Building Transition Plan was given by DSWA in February 1995 after several iterations and briefings at the ITWG meetings held during 1994. ITT distributed the document to all members of the ITWG. The following sections describe the Transition Plan.

### 5.3.1 Building Transition Plan

The purpose of the Building Transition Plan was to describe the approach to be used to transition the DECADE main building from the Corps of Engineers to the AEDC Base Civil Engineer (BCE) with DSWA concurrence and to initiate operation and maintenance responsibilities by AEDC Director of Operations personnel. Since a formal test plan for the entire building was not required from the building contractor by the COE, the transition plan delineated events to be performed for DSWA/AF acceptance of the DECADE building, in accordance with the element testing philosophy of the Management Plan for Acceptance of the DECADE Facility.

The Corps of Engineers followed the Department of the Army regulation No. 415-345-38, ER 415-345-38, entitled "Construction Transfer and Warranties." DSWA followed the AEDC guidelines for conducting Readiness Reviews. The events involved in acceptance of the building are depicted in Figure 5-1.

ITT and several other ITWG members, selected by DSWA, participated in the Building Readiness Review. We reviewed the items listed in Table 5-1 for completeness and sufficiency to meet DSWA requirements. Review of the contractual submittals was

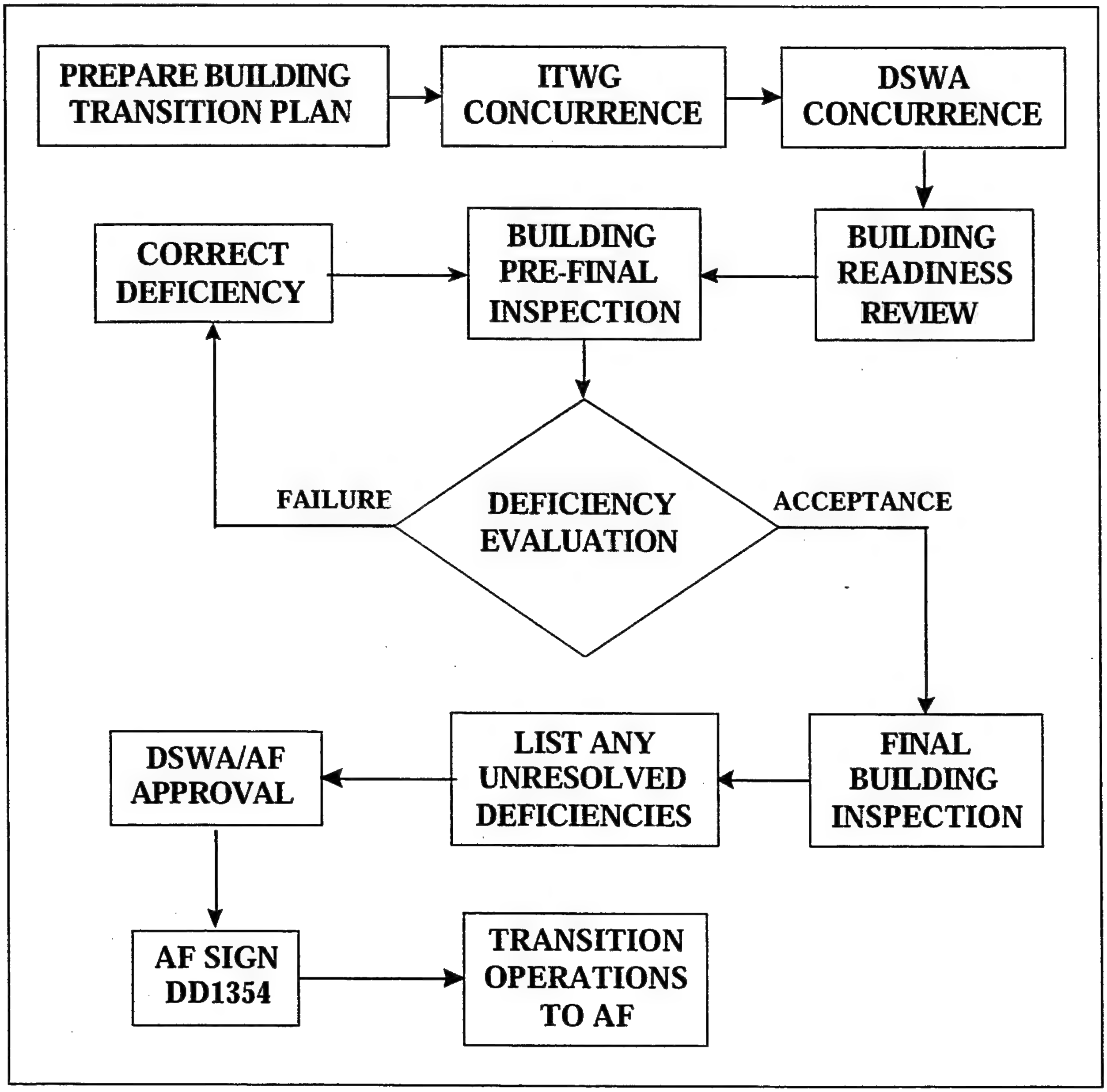



**Figure 5-1. Building Transition Flow Diagram**

primarily performed by Corps and AEDC BCE personnel. The training records, interface verification, and System Safety Hazard Analysis were reviewed by AEDC, ITT and other selected members of the ITWG.

ITT reviewed the specifications and interfaces to determine critical items that should be independently verified. We generated a table called the On-site Building Verification Requirements (OBVR) which became the focus for guiding the building acceptance process. ITT, SvT and the COE performed verification of the various items on the list. A sample sheet listing some of the ITT responsibilities is shown in Table 5-2. ITT also developed the Building Subsystems checklist, shown in Table 5-3, to assist in determining

**Table 5-1. Building Readiness Review Items**

| |
|---|
| Resolution of Functional and Physical Configuration Deficiencies |
| As-Built Drawings |
| Specifications and Approved Changes |
| Interface Verification |
| Operating Procedures/Instructions |
| Maintenance Procedures/Instructions |
| System Safety Hazard Analyses |
| Spare Parts Lists and Availability |
| Technical Manuals |
| Training and Certification Material |
| Personnel Training Records |
| Troubleshooting Procedures/Instructions |

the completion of critical items. Satisfactory completion of these tables, delivery of all the required submittals, and resolution of any deficiencies identified during readiness review will ensure that all the contractual requirements for acceptance have been fulfilled.

During January and February, 1996, the COE invited the ITWG to participate in several pre-inspections of the building. ITT documented deficiencies noted during those tours, and the COE allowed the building contractor to correct them before the final inspection in

**Table 5-2. On-site Building Verification Requirements**

| *No.* | *Interface/Building Subelement* | *Description of Verification Required* | *Recommended Responsible Party* | *Status* |
|---|---|---|---|---|
| 1.0 | Trigger Control, Machine DAS, RICC, HVPS, and SF6 Recovery system cables and plumbing to Building Cable Conduit in Equipment Trench | Verify existence, location, and dimensions of conduit in equipment trenches. (ICD lists as 4 conduit per trench, @ 12" dia. each) | ITT | Complete. Dimensions verified as documented in ITT memo dtd. 7 Mar 95 |
| 2.0 | PEOS Driver Cables and Vacuum System Plumbing to BER Sleeve Penetrations | Verify existence, location, and dimensions of sleeve penetrations. (ICD lists 14 total, @ 12" dia. each) | ITT | Complete. Dimensions verified as documented in ITT memo dtd. 7 Mar 95 |
| 3.0 | Marx HVPS to Building Conduit in Room 163 | Verify existence, location, and dimensions of conduit. (ICD lists as 4 - 6" PVC stubbed up in NW corner of room 163 and terminating in north tunnel wall) | ITT | Complete. Dimensions verified as documented in ITT memo dtd. 7 Mar 95 |
| 4.0 | Various Cabling to Control Room and Baby SCIF Feedthru Panels | Verify existence, location, and size of panels. | ITT | Open. |
| 5.0 | Tunnel Access Grating | Verify pass-thru dimensions and clearances of all access grating. | ITT | Complete. Clear openings for each access are as documented in 3 Oct 95 ITT memo. Hatches in 161 & 163 are solid steel, hence have no pass-thru dimensions. |
| 6.0 | Simulator Deionized Water System to Building Water System (Simulator Quads) | Verify existence, location and dimensions of building supply and return line terminations at each of the four quads. (ICD lists as 4" 150lb ANSI flanges, @ 1 supply and 1 return at each quad) | ITT | Complete. Dimensions verified as documented in ITT memo dtd. 7 Mar 95 |

February. The signed transfer document, DD Form 1354, certifying completion of the work was furnished by the Contracting Officer (COR) to the AF/AEDC BCE at the time

of the final inspection. Deficiencies disclosed during the inspection were listed on the reverse of the form for resolution following transfer. The Corps delivered all building-related documentation to the AEDC, DSWA's representative for operation and maintenance of the DECADE facility.

The deficiencies noted on the back of the DD Form 1354 were classified by the COR as either contract deficiencies or those not within the scope of the contract documents. The COR provided for correction of appropriate contract deficiencies and notified DSWA and the BCE of items which were not within the scope of the contract. He also informed DSWA and the BCE in writing of action to be taken on deficiencies not within the scope of the contract. Since February 1996, almost all contract deficiencies have been corrected, and the COR certified those corrections on the appropriate copy of the DD Form 1354.

**Table 5-3. Building Subsystem Completion Checklist**

| Building "Subsystem" | Testing Required by Specs | Test Done | Submittals Approved | Training Completed |
|---|---|---|---|---|
| Driveway | - Sample & construction testing<br>- Contractor inspections<br>- Grade & smoothness tests | Yes | Yes | - |
| Slab, wall, roof concrete | - Samples & test for strength<br>- Certificate of compliance | Yes | Yes | - |
| Test platform | - Samples tested<br>- Certificate of compliance | Yes | Yes | - |
| Trench grating | None | - | Yes | - |
| Moisture protection | None | - | Yes | - |
| Raised flooring | - Concentrated load tests<br>- Certificate of compliance | Yes | Yes | - |
| Plumbing | - Pressure, leakage, flushing, and sterilization tests<br>- Operational test<br>- Tests on samples<br>- Certificate of compliance | No | No | - |
| Equipment lift | None | - | No | - |
| Personnel lift | None | - | No | - |
| Doors | None | - | Yes | - |
| HVAC air distribution and ventilation | - Performance, functional, field, and operational tests. | No | No | No |
| Refrigeration equipment (air conditioning) | - Performance, functionality, and field tests. | No | No | No |
| Hot water system | - Plumbing tests apply (see above)<br>- Operational tests | No | No | No |
| HVAC controls | - Test control systems<br>- Functional performance tests | No | No | No |
| Oil/Water storage tanks | - Inspect IAW ASME code<br>- Hydrostatic testing | No | Yes | - |
| Oil/DI water distribution | - Piping pressure test on pipes<br>- Operational tests<br>- Plumbing tests apply (see above) | No | No | - |
| Equipment cooling water distribution | - Operational tests<br>- Plumbing tests apply (see above) | No | No | No |

With the execution of the 1354, the building is now fully operational. AEDC will continue to notify COE of any latent deficiencies discovered and they will be resolved as appropriate. ITT has reported the resolution of all annotated deficiencies to DSWA and has identified and addressed many other building related deliverable requirements not included as construction deficiencies (for example, training on the operation of various building subsystems).

### 5.3.2 Support Building Transition Plan

The Support Building Plan is identical in form to the Building Transition Plan.

## 5.4 INTEGRATED SYSTEM TEST PLANNING

### 5.4.1 Modification of Planning Approach

An integrated test plan has been under development and a draft was to be delivered in June of 1995. However, restructuring of the program to accommodate the simulator switch development has changed the original concept of the integrated test plan. It was to contain any integration tests not covered in the element test plans and any tests deemed necessary to assure integrated operation of the DECADE facility with the simulator. Associated test procedures would have been developed. Now since the simulator will not be installed when the other elements are completed and the facility ready for simulator installation, we have modified the test plan to consist of integration items that were not tested during the element testing and tests that will be required when the simulator is available. Such tests will include effects of radiation on the adjacent components (motors, radiation shielding of the Atomic Doors, effect on security access components, noise floor on cables during simulator operation, etc.). These issues and recommendations have all been documented in our DECADE System Integration Issues Report submitted to DSWA.

PPI should address many of these tests in their DECADE Quad test plan, though they are unlikely to accept responsibility for all of them. DSWA, as the official integrator, will have to conduct those tests or delegate that responsibility to whoever is providing integration support at that time. We have evaluated all of the simulator interfaces identified in the DECADE ICD and considered other "unintentional," functionally related interfaces. The report contains a list of integrated tests that we believe are warranted and identifies who we think is responsible for conducting those tests. We will continue to modify this list and support test planning if the schedule is consistent with our period of performance.

### 5.4.2 Reporting

ITT personnel have generated several reports to document all aspects of the DECADE integrated test program. These consist of acceptance reports for each element documenting the results of the element's readiness review, training performed, any specific on-site verification done, resolution of deficiencies, and any outstanding issues or other applicable acceptance documentation. A typical acceptance report format is shown

in Figure 5-2. At the conclusion of all the element acceptance tests, an integrated acceptance final report was produced summarizing the entire acceptance process. The readiness review and turnover to AEDC for operation and maintenance for each element occurred on the following dates:

| | |
|---|---|
| UDAS Shielded Enclosure | 28 March 1996 |
| Building/SUpport Building | 29 August 1996 |
| Safety and Security System | 14 March 1997 |
| UDAS | 16 July 1997 |

- **Introduction**
  - Use of Transition Plans
  - Use AEDC Readiness Review Items as a Guide
  - Follow Army Regulation ER 415-345-38
- **Readiness Review Items (Documentation Status/Location)**
  - As-built Drawings
  - Resolution of Any Functional/Physical Configuration Deficiency
  - Specifications and Approved Changes
  - Operating Procedures/Instructions
  - Maintenance Procedures/Instructions
  - Spare Parts Lists and Availability
  - Technical Manuals
  - Troubleshooting Procedures/Instructions
- **Specific Interface Verification**
  - OBVR Results Included in Appendix
- **System Safety Hazard Analysis**
  - Reference System Hazard Analysis Document
- **Training Material and Records**
  - Reference AEDC Records
- **DD 1354 Process**
  - BO Documentation
  - Final Documentation
  - Deficiencies and Their Resolution
  - Support Material Located in Appendices
- **Summary**
  - Overall Status of Acceptance
  - Any Outstanding Issues

**Figure 5-2. Building/Support Building Acceptance Report Format**

# 6. USER TRAINING DEVELOPMENT

## 6.1 BACKGROUND

During the course of the DECADE program, multimedia concepts were to be used to develop several user training tools. These were to culminate in three products, described in Section 6.2, to assist potential users become familiar with the facility. The products included a User Operations Handbook, User Operations On-line Handbook, and a User Operations Video. Although gathering of the information was to be performed throughout the contract period a majority of the work was to be done during the last 12 months of the contract with delivery prior to IOC of the facility.

## 6.2 PLANNED USER TRAINING DOCUMENTS

During the first two years of this contract, a low level of effort was expended on gathering data to support the three products to be developed for user training about the DECADE facility.

During the February 1994 PMR an outline of the handbook and multimedia techniques to be used for this task were presented at a User Operations Tools pre-PDR. An reevaluation of the need for these tools was performed shortly thereafter by ITT, AEDC, and DSWA personnel. It was decided that more benefit would be gained from two alternative products describing the DECADE facility: a color brochure describing DECADE capabilities and a 10 - 14 page manual giving general information on the DECADE facility.

While none of the early efforts reached completion due to the redirection by DSWA, most of the data gathered was exploited for the development of the two alternative products which were completed or planned (see Section 6.3).

## 6.3 USER TRAINING MATERIALS DEVELOPED

The evolution of DECADE requirements described above led to the decision that the most effective tools for use on the DECADE program during this phase would be a one page brochure to be handed out to potential customers and a short manual providing basic information and capabilities for the DECADE facility.

### 6.3.1 DECADE Flyer/Brochure

Since the 1995 HEART conference in Albuquerque was the first opportunity to present information on DECADE to the user community, DSWA decided to place priority on the production of the brochure and reduce the effort on the manual until closer to the time of acceptance of the building.

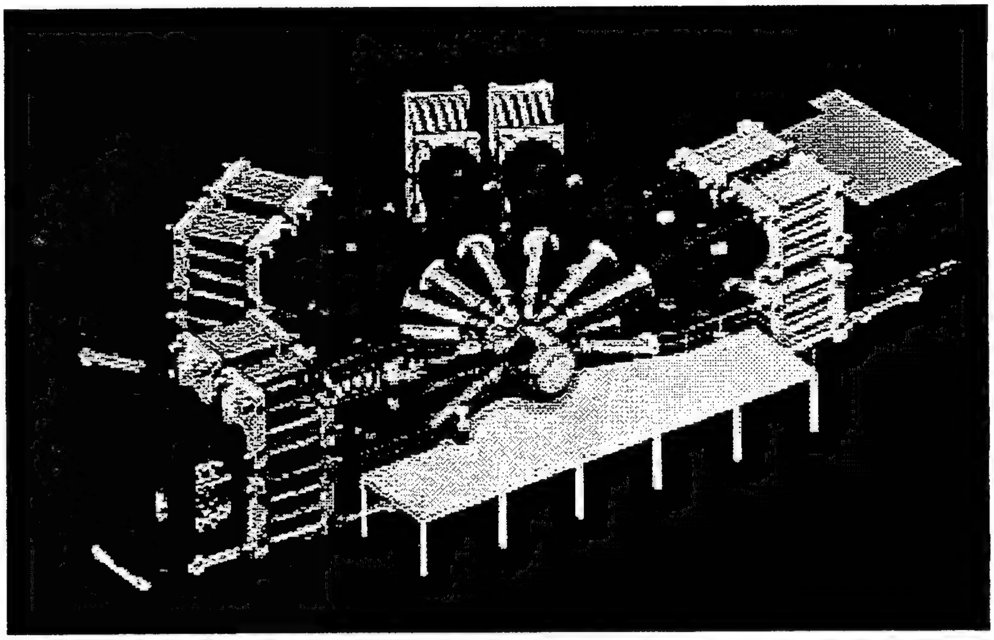
The purpose of the brochure was to provide concise information on the DECADE Facility that could be given to a potential user and provide him with enough information to know what the simulator was, some of its capabilities, and who should be contacted for further information.

Based upon information from similar facilities, the handout was to contain, as a minimum, the following items:

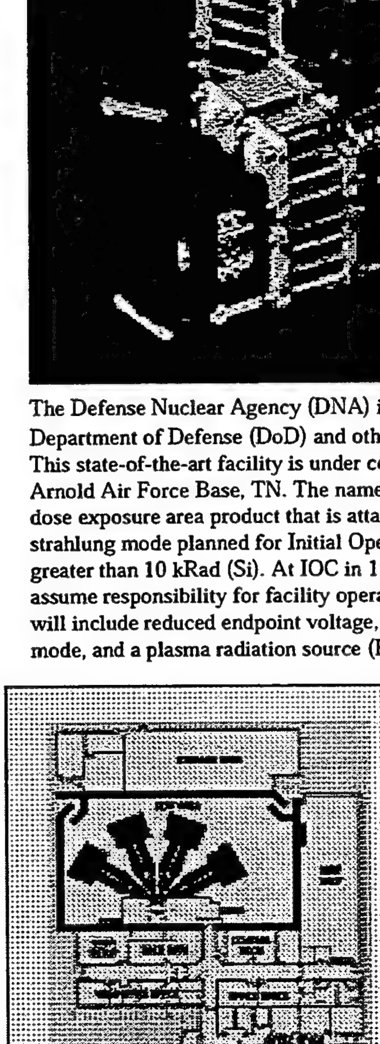
1. introduction to DECADE (effects simulated and uniqueness),
2. advantages of using DECADE,
3. color rendition of the simulator,
4. interior layout showing user rooms (if there is space on page),
5. basic capabilities of the simulator,
6. available equipment,
7. analysis capability (codes, computers, etc.),
8. small map of where AEDC is located,
9. list sponsor/operators, and
10. points of contact for more information.

AEDC graphics personnel provided the DECADE, DSWA, AEDC, and AF Materiel Command Logos. PPI delivered an artists rendition of the simulator. All of these were digitized and included in the brochure.

# DECADE WORLD'S LARGEST X-RAY SIMULATION FACILITY



The Defense Nuclear Agency (DNA) is building the DECADE X-ray Facility to verify that critical Department of Defense (DoD) and other systems can perform their missions in harsh radiation environments. This state-of-the-art facility is under construction at Arnold Engineering Development Center (AEDC) on Arnold Air Force Base, TN. The name DECADE arose from the goal of an order of magnitude increase in the dose exposure area product that is attainable at existing DoD facilities. At present, the large area bremsstrahlung mode planned for Initial Operating Capability (IOC) will have an exposure area of 1 $m^2$ and dose of greater than 10 kRad (Si). At IOC in 1996, DECADE will be turned over to the Air Force (AEDC), which will assume responsibility for facility operations and maintenance. Planned Product Performance Improvements will include reduced endpoint voltage, reduced pulsewidth, multiple pulses, a small area bremsstrahlung mode, and a plasma radiation source (PRS) capability that will include Al and Ar radiation lines.



The Facility is designed with a number of user-oriented features: 1,000 ft of floor space for user data acquisition needs, dedicated test setup area, user shop, and classified testing capability, along with data analysis and storage capabilities.

DECADE will be the only DoD aboveground x-ray simulator capable of testing entire large-area operating electronic ensembles such as satellite surveillance, communication, and missile navigation sub-systems. The primary purpose of this premier test facility is to provide a user-friendly systems developer test capability; however, the simulator may also be used to develop and advance technologies for x-ray simulators. The simulator will produce 30-40 terawatts of power for a period of 40-50 nanoseconds. The energy required to produce the x-rays is stored in the Marx capacitor banks at the rear of the simulator. The Marx banks are discharged through closing switches, pulse forming lines, magnetically insulated transmission lines (MITL), and a plasma opening switch (POS). Upon opening of the POS, the resulting energy pulse is derived from the energy being released to the diode source plate through the downstream MITL. The diode converts the electrical energy to x-rays through the bremsstrahlung process. These x-rays expose the test article, which is located in a vacuum chamber or ambient conditions. Test articles up to 1.5 m diameter and 2 m length can be accommodated in the vacuum chamber; larger test articles may be tested at ambient conditions.

**Figure 6-1. DECADE Brochure (front)**

## Defense Nuclear Agency DECADE X-ray Simulator Characteristics

**Radiation Source Specifications:**

| Source | Average Yield*/Dose | U** | Area | Pulse Width FWHM | Average Peak Diode Voltage not to exceed |
|---|---|---|---|---|---|
| Bremsstrahlung | 10-13 kRad(Si) | 2.0 | 10,000 $cm^2$ | $\leq$ 50 ns | 1.5 MV |

* Area-weighted average

** Uniformity (U) is defined as the ratio of Maximum Radiation to Minimum Radiation over the total area measured in a rectangle with an Aspect Ration less than or equal to 1.2:1.0

**Fully Rated Operations:** The facility has the capability to support three shots a day. It can be configured to accommodate various security levels including sensitive compartmented information.

**User Data Acquisition System (UDAS):** The data storage and management system capability is sufficient to record, analyze, and archive collected data. For personal computer hookup, the UDAS network design supports both IBM and Macintosh computers with an Ethernet connection. The UDAS will use DEC Pathworks networking software, which supports Windows for Work Groups, Windows-NT, DECnet, TCP/IP, and Appletalk.

**UDAS User workstation Hardware:**

- DEC 2100/500MP "SABLE"
- 64 MBytes memory
- 2 GBytes disk storage
- 20 GByte linear tape, CD-ROM, 4 mm DAT tape, 9 track tape
- Two weeks on-line archival of test data

**UDAS Software:**

- VMS, Windows-NT, OSF/1 operating systems
- FORTRAN and C compilers and optimizing pre-compilers
- DECnet, TCP/IP, NFS Network Software

**Security:**

- C2 rated operating system
- Classified and unclassified removable disks

**Instrumentation:**

- Initial instrument setup in less than four hours
- Processed data available in 20 minutes after shot
- Quick look within five minutes to permit planning for next shot parameters
- Noise floor ~10 mV peak during pulse, 10 μV after 100 μs
- 148 channels available at IOC (expansion to 350 is planned)

**Equipment Parameters:**

| Analog Bandwidth | Sampling Rate (samples/sec) | Number of Channels |
|---|---|---|
| DC — 1 GHz | 4 G | 5 |
| DC — 400 MHz | 2 G | 47 |
| DC — 100 MHz | 500 M | 32 |
| DC — 10 MHz | 50 M | 32 |
| DC — 100 KHz | 500 K | 32 |

**Direct Digital Data Recording Systems (DRS):** Two complete systems are available:

- Ethernet interface for communication with UDAS network
- Acquisition of 64 bit digital data at 12.5 MHz data rate
- 512 Mbytes of data memory
- Inputs for gating (trigger) signal and fiducial signal
- Data downloaded via DECADE computer network

**Test Support:** AEDC is a full service test complex with vast experience in space, aeromechanical and propulsion testing. An established test infrastructure permits excellent customer interactions ranging from pre-test analysis to test planning to evaluation of test data. Fiber optic links are connected to AEDC Convex and Cray mainframes for additional computational resources. Various codes are available to perform analysis of circuits, pulse power, radiation sources, and effects on electronics.

**Contacts:**

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**Figure 6-2. DECADE Brochure (back)**

Various Drafts of the brochure were reviewed at the ITWGs held during the last half of 1994 and early part of 1995. Comments were received from all reviewers and incorporated into the flyer. DSWA approved the brochure contents in February 1995. Following approval, ITT produced and delivered a thousand copies of the brochure to DSWA, AEDC, and to the HEART conference during February and March 1995. Images of the front and back of the one-page double-sided flyer are shown in Figures 6-1 and 6-2.

After delivery of the flyer and distribution at the HEART conference, discussions were held with Lt. Col. Myers and AEDC personnel concerning an update to the flyer. From these discussions it was determined that a revision to the flyer was not necessary, but rather a 10 to 14 page brochure should be produced. The brochure should expand on the flyer and include user interactions with the facility. As a result, the information in the flyer and user information was combined into the deliverable for the User Guide described in the next section.

6.3.2 User's Guide for the DECADE Radiation Facilities at AEDC

At the onset of the DECADE program this document was to be a comprehensive users manual, containing all the information necessary for the interaction of the user with the DECADE facility. The resulting document, with minor modifications, was to become a chapter in the "AEDC Test Facilities Handbook," describing how a user would interface with the DECADE facility for the performance of a test. There were many ITWG discussions with Lt. Col. Myers and AEDC personnel regarding the utility of producing the users guide (as originally conceived) and an update to the DECADE flyer. The results of these discussions were that, due to the projected 1998 date for simulator completion, the project would best be served by combining the flyer and the users guide into a 10 to 14 page brochure describing DECADE facility user issues. The title of the new document would remain "User's Guide for the DECADE Radiation Facilities at AEDC," although it would be less comprehensive than originally envisioned.

The purpose of the User's Guide (although incomplete) is to familiarize potential test and evaluation sponsors and users with the operating procedures involved in scheduling, planning, and conducting a test and evaluation program at the DECADE facility. It also includes basic information on the simulator, the user areas, and visitor procedures. Since the DECADE simulator will not be installed until well after the ITT integration contract is completed, the details on the simulator and the radiation patterns will need to be filled in by AEDC as the design becomes finalized and characterizations are performed. AEDC plans to use the document as a starting point to produce the DECADE Facility chapter of the "AEDC Test Facilities Handbook." Details on other simulators such as the proposed PRS machine and the MBS will also need to be incorporated into that chapter.

# 7. TECHNICAL PUBLICATIONS DATA

## 7.1 DATA REPOSITORY

As the systems integrator, ITT was responsible for the collection, recording, and filing of all documentation, information, and data related to the DECADE program. We requested that a copy of contractual submittals from each DECADE contractor be forwarded to the Alexandria office. When that did not occur, we requested copies from the contractor or from the PMO. ITT established a separate office area to maintain the DECADE Data Repository, and sorted the contents according to each element and documentation type.

The data repository contains contract submittals, drawings, acceptance data, meeting notes and agendas, and Systems Engineering and program reports from each element of the DECADE program. This information has been very valuable and utilized numerous times by the ITT staff as a historical reference for verifying original program requirements were being adequately addressed during design and installation phases of the project. ITT distributed information from the repository on an as-requested basis, so that other team members could perform similar analyses. ITT was a central location for serving these needs.

As ITT's contract nears completion, we are working with AEDC DECADE personnel and with FCDSWA to determine what data are useful for retention. These data will be shipped to AEDC and incorporated into the Facility Baseline File Index.. ITT's development of the Operation and Maintenance Manual for the facility will be based on this historical information. The manual will call out references to pertinent documentation where appropriate.

Two specific technical documents required from ITT during this contract were the User Requirements Questionnaire and Analysis and the integrated facility Operations and Maintenance Manual. These documents are described in the following sections.

## 7.2 DECADE FACILITY USER REQUIREMENTS QUESTIONNAIRE

ITT produced a DECADE Facility User Requirements Questionnaire during the first year of our DECADE integration support effort. The purpose of the questionnaire was to poll the nuclear weapons effects community on their requirements for the facility. Consistent with DNA's desire that DECADE be a world class radiation test facility, the questionnaire was extensive. We asked about 100 questions in an easy-to-answer format, addressing the topics listed in Table 7-1.

The questionnaire was sent to 173 members of the nuclear weapons effects community, and 17 responses were received. ITT analyzed responses and published results in a report to the DECADE community. Our analysis report served as the basis for initial DECADE building floor space requirements and initial selection of UDAS equipment and computers. This knowledge contributed to the establishment of UDAS requirements, SCIF layout, and initial diagnostics and instrument requirements.

**Table 7-1. User Questionnaire Topics**

- General Requirements
- Source Requirements
- Vacuum Chamber Requirements
- Data Acquisition System Requirements
  - Main Data Acquisition Room
  - User Data Acquisition Room
  - User Data Acquisition Computers
  - Trailer Park Requirements
  - User Specific Needs
- Upgrade Suggestions
- Clean Room Requirements
- Workspace Requirements

## 7.3 FACILITY O&M MANUAL

The DECADE Facility O&M Manual consists of all the DECADE Element's O&M documentation available for the DECADE Facility. With the delay of the simulator installation, the components of the manual will consist of information from each of the remaining elements listed in Table 7-2.

**Table 7-2. DECADE Element and DSWA Agent**

| DECADE ELEMENT | DNA Executing Agent |
|---|---|
| Building | US Army Corps of Engineers |
| Support Building | US Army Corps of Engineers |
| User Data Acquisition System | NISE East Norfolk |
| UDAS Shielded Enclosure | AEDC |
| Safety and Security System | NISE East Charleston |

As part of the submittal process for each of the elements, typically, the O&M manuals for the element and its subsystems were due within 90 days of the acceptance of the element. DSWA has requested that each executing agent deliver the final submittals directly to AEDC for storage in the DECADE Facility. The Facility O&M Manual lists all the manuals from each of the elements. This document provides a source to readily

identify the existence and location of any of the O&M manuals produced for the DECADE program.

# 8. TRANSITION TO FCDSWA

## 8.1 TRANSITION OF SE/I RESPONSIBILITIES TO FCDSWA

HQDSWA identified an individual (Mike Zmuda) to be based on-site at AEDC beginning in the fall of 1997. ITT team members met with Mr. Zmuda on several occasions to discuss remaining Systems Engineering issues, in addition to historical data.

ITT & DSWA agreed that the key items/activities to transition were:

- Action Item Database - ITT converted the database to Microsoft Access, which is more standard than RBASE, which had been used throughout the life of the contract
- Configuration Management/Interface Control - ITT updated the CM Plan just before the end of the contract. The objective was to simplify it, reduce approval times, and focus the plan on the current phawse of the program. Revisions were coordinated with the community. ITT also turned over the ICD (Microsoft Word format), which accurately reflected the as-built conditions. We also highlighted those aspects that the Systems Integrator must focus on as the simulator design is finalized.
- Testing philosophies - ITT highlighted the acceptance methodology that was utilized prior to the end of this contract. We also provided a brief report identifying several integration-type tests that should be considered after quad installation is complete.
- Data - ITT shipped all of our program files to Mr. Zmuda at the end of the contract. We pointed out the documents that will have immediate value and identified those items that only have historic benefit.
- Schedule Management - We discussed our coordination/schedule management philosophies with Mr. Zmuda on several occasions. Though not as critical at this stage of the program, ITT believed an integrated schedule would still reduce the overall program risk. The notion of an automated software tool was not widely supported, so we suggested ways Mr. Zmuda could manage schedule issues and conflicts.

## Appendix A
## ITT SUPPORTED MEETINGS

### 1991

Building Requirements Working Group at HQ DSWA, March 4, 1991.

Building Project Status Review at LAN, Houston, TX, March 13-14, 1991.

Physics International (PPI) DECADE Status Review at Arnold Engineering Development Center (AEDC), Tullahoma, TN, March 18-19, 1991.

A/E Guidance Meeting at ITT Systems & Sciences (ITT S&SC), Alexandria, VA, March 19-20, 1991.

Facility Inspection Visits to Sandia, Maxwell, and Physics International, April 1-4, 1991

Building Design Issue Resolution Meeting at ITT S&SC, Alexandria, VA, April 11-12, 1991.

Maxwell Laboratories (MLI) DECADE Status Review at AEDC, April 23, 1991.

Fact-finding trip to Sandia National Laboratories (SNL), Albuquerque, NM; PPI, San Leandro, CA; MLI, San Diego, CA, April 24-26, 1991.

Building 15% Design Review Working Group meeting at ITT S&SC, Alexandria, VA, April 26, 1991.

Building 15% Design Review at LAN, May 1, 1991.

PPI Redesign Review meeting at ITT S&SC, Alexandria, VA, May 2, 1991.

Building 15% Redesign Preview meeting at LAN, May 14-15, 1991.

Simulator Conceptual Design Review at PPI, May 29, 1991.

Pulsed Power Conference, San Diego, CA, June 17-19, 1991.

HQDSWA Users Requirements Review at Aerospace Corporation, El Segundo, CA, June 20-21, 1991.

Building 15% Redesign Review at LAN, June 27-28, 1991.

Reviews of pre-release DECADE Draft Statement of Work, at Naval Research Laboratories, Washington, DC, July 1, 1991, and at ITT S&SC Alexandria, July 3, 1991.

PMO Coordination Meeting with Integration Team at ITT Systems & Sciences, Colorado Springs, July 28-29, 1991

Building Design Status Review at LAN, August 14, 1991.

DECADE Briefing to Director (MG Watson) by DFRA at DSWA, August 28, 1991

Program Management Review (PMR) at AEDC, September 19, 1991.

Grounding and RF Shielding Technical Advisory Group (TAG) Meeting at LAN, September 30, 1991.

Building 30% Design Review at LAN, September 30 - October 1, 1991.

Building Design Issues meeting at ITT S&SC, Alexandria, VA, October 10, 1991.

Radiation Shielding TAG Meeting at ITT S&SC, Alexandria, VA, October 18, 1991.

Security Issues Meeting at AEDC, October 21, 1991.

Security Meeting at AEDC, October 28, 1991

Value Engineering Review at LAN, October 29, 1991.

Configuration Control Board (CCB) Meeting at HQDSWA, November 6, 1991.

PMR at HQDSWA, November 8, 1991.

User DAS Cable Plant Requirements Meeting at HQDSWA, November 15, 1991.

Simulator RFP Working Group Meetings at ITT S&SC, Alexandria, VA, November 19-22, 1991.

**1992**

SE/IS Contract Briefing to Col Yelmgren at ITT S&SC, Alexandria, VA, January 21, 1992.

Building Design Issues Resolution Meeting at LAN, January 22, 1992.

PMR at HQDSWA, January 29, 1992.

Hardened Electronics and Radiation Technology (HEART) meeting at SNL, February 24-28, 1992.

TAG Meeting to Review Simulator Demonstration Program Data at RDA, February 12, 1992.

Simulator Contract SSEB Meetings at ITT S&SC, Alexandria, VA, March 2-27, 1992.

Building 60% Design Review at LAN, March 11-12, 1992.

Building Issues Meeting at LAN, April 8-9, 1992.

PMR at Mobile, AL, April 29, 1992.

Partnering Workshop at Mobile, April 30 - May 1, 1992.

Review at LAN, May 10-11, 1992.

Building 90% Design Review at LAN, June 10-11, 1992.

PMR at HQDSWA, June 18, 1992.

"On-Board" Building Design Review at LAN, June 25, 1992.

User DAS/Diagnostics Steering Group Meeting at ITT S&SC, Alexandria, VA, July 22, 1992.

TAG Meeting to Review Proposed Simulator Change at ITT S&SC, Alexandria, VA, July 31, 1992.

PMR at PPI, August 4, 1992.

Simulator Back End PDR and Front End SCDR at PPI, August 5-6, 1992.

CCB Meeting at PPI, August 6, 1992.

Building Project Status Review at LAN, August 13, 1992.

CCB Meeting at ITT S&SC, Alexandria, VA, August 18, 1992.

Configuration Management Working Group Meeting at ITT S&SC, Alexandria, VA, August 18, 1992.

User DAS/Diagnostics Steering Group Meeting at ITT S&SC, Alexandria, VA, September 2, 1992.

Configuration Management Working Group Meeting at AEDC, September 10, 1992.

Building Redesign Coordination Meeting at LAN, September 15, 1992.

PMR at Mobile, AL, September 16, 1992.

Simulator Technical Interchange Meeting (TIM) at Mobile, AL, September 17, 1992.

User DAS/Diagnostics Steering Group Meeting at PPI, October 8, 1992.

Access Control System Design Meeting at H&N, Albuquerque, NM, October 14, 1992.

Simulator TIM at SNL, October 14, 1992.

PMR at SNL, October 15, 1992.

Cost/Schedule Status Report (C/SSR) Tutorial at ITT S&SC, Alexandria, VA, October 19, 1992.

"On-Board" Building Design Review at LAN, October 29, 1992.

Simulation Fidelity Workshop at Huntsville, AL, December 1-3, 1992.

Plasma Opening Switch Workshop at PPI, December 14-15, 1992.

Simulator TIM at PPI, December 16, 1992.

PMR at PPI, December 16, 1992.

**1993**

TAG Meeting to Review ICC and Machine DAS Requirements at AEDC, January 12, 1993.

PMR at AEDC, January 13, 1993.

Radiation Licensing Meeting at TN Dept. of Health and Environment, Nashville, TN, January 14, 1993.

Meeting with PMO to Outbrief Results of Radiation Licensing Meeting at HQDSWA, January 15, 1993.

Hardened Electronics and Radiation Technology (HEART) Conference at Orlando, FL, February 1-5, 1993.

Ground Breaking Ceremony at AEDC, February 9, 1993.

Program Management Review at AEDC, February 10, 1993.

Partnering Workshop at AEDC, February 11-12, 1993.

Grounding and Shielding Meeting at ITT S&SC, Albuquerque, NM, March 10, 1993.

Simulator Scheduling Meeting at PPI, April 12-13, 1993.

Simulator TIM at PPI, April 14,1993.

PMR at PPI, April 15, 1993.

Building Working Group (BWG) Meeting at AEDC, June 22, 1993.

Simulator TIM at FCDSWA, June 23 ,1993.

PMR at FCDSWA, June 24, 1993.

Simulator Scheduling Meeting at PPI, June 29, 1993.

BWG Meeting at AEDC, July 21 ,1993.

Grounding Meeting at AEDC, July 21, 1993.

User DAS Status Meeting at AEDC, July 21, 1993.

Redesign Meeting for UDAS Cable Ways at LAN, July 29, 1993.

BWG Meeting at AEDC, August 17, 1993.

Simulator TIM at PPI, August 18,1993.

PMR at PPI, August 19, 1993.

System Safety Working Group (SSWG) Meeting at AEDC, September 21, 1993.

BWG Meeting at AEDC, September 21, 1993.

Simulator Status Meeting at HQDSWA, October 5, 1993.

User DAS System Requirements Review at AEDC, October 19-20, 1993.

Simulator TIM at AEDC, October 21,1993.

Meeting with AEDC Public Affairs and Graphics Personnel on User Operations Training Tools, October 21, 1993.

Integration Working Group (IWG) Meeting at AEDC, October 21, 1993.

PMR at AEDC, October 22, 1993.

DECADE Assessment Team Kick-Off Meeting at ITT S&SC, Alexandria, VA, November 12, 1993.

BWG Meeting at AEDC, November 17, 1993.

Simulator Technical Working Group Meeting (STWG) at PPI, December 8, 1993.

IWG Meeting at PPI, December 8, 1993.

PMR at PPI, December 9, 1993.

**1994**

DECADE Planning Meeting with DSMC at HQDSWA, January 5, 1994.

User DAS Shielded Enclosure Planning Meeting with NISE East at HQDSWA, January 14, 1994.

User DAS Shielded Enclosure Planning Meeting with NISE East at HQDSWA, January 20, 1994.

SSWG Meeting at AEDC, January 25, 1994.

BWG Meeting at AEDC, January 25, 1994.

User DAS System Functional Review at AEDC, January 26, 1994.

IWG Meeting at ITT S&SC, Alexandria, VA, February 8, 1994.

User Training Tools Decision Meeting at ITT S&SC, Alexandria, VA, February 9, 1994.

Simulator RICC, Triggers and MDAS PDRs at PPI, February 22-23, 1994.

Simulator Front End pre-PDR at PPI, February 23, 1994.

Radiation Diagnostics Meeting at Science Research Lab, Alameda, CA, February 24, 1994.

PMR at PPI, February 24, 1994.

Simulator Remediation Plan Meeting at PPI, March 14, 1994.

Building Beneficial Occupancy Meeting at AEDC, March 15, 1994.

BWG Meeting at AEDC, March 15, 1994.

IWG Meeting at PPI, March 22, 1994.

Simulator Marx, TC, Oil, DI Water, $SF_6$ and Vacuum CDRs at PPI, March 23-24, 1994.

Radiation Licensing Meeting at PPI, March 24, 1994.

Safety and Security System (SSS) Meeting at NISE East, Charleston, SC, April 5, 1994.

User DAS Shielded Enclosure Meeting at MMM Design Group, Norfolk, VA, April 7, 1994.

Simulator RICC/SSS/Building Interface Teleconference, April 13, 1994.

PMR at AEDC, April 26, 1994.

Instrumentation and Diagnostics Working Group Meeting at AEDC, April 27, 1994.

IWG Meeting at AEDC, April 27, 1994.

SSWG Meeting at AEDC, April 27, 1994.

User Requirements Meeting at HQDSWA, May 5, 1994.

Simulator Remediation Plan Meeting at PPI, May 10, 1994.

Simulator Oil, $SF_6$, and Trigger CDRs at PPI, May 24-25, 1994.

User DAS Shielded Enclosure Requirements Meeting at HQDSWA, June 1, 1994.

Simulator Remediation Plan Meeting at PPI, June 16-17, 1994.

Platform Redesign Meeting at LAN, June 22, 1994.

Partnering Workshop at AEDC, June 28, 1994.

PMR at AEDC, June 29, 1994.

User DAS Shielded Enclosure Technical Meeting at AEDC, June 30, 1994.

SSS Technical Meeting at AEDC, July 12, 1994.

IWG Meeting at AEDC, July 13, 1994.

SSWG Meeting at AEDC, July 14, 1994.

BWG Meeting at AEDC, July 14, 1994.

User DAS PDR at AEDC, August 9-10, 1994.

User DAS Shielded Enclosure 35% Design Review at MMM Design Group, Norfolk, VA, August 16-17, 1994.

PMR at ITT S&SC, Alexandria, VA, August 23, 1994.

Integration and Test Working Group (ITWG) Meeting at ITT S&SC, Alexandria, VA, August 24, 1994.

PPI Resource Requirements Meeting at PPI, September 14-15, 1994.

SSS Meeting at NISE East, Charleston, SC, September 21, 1994.

Review of DM-1 Test Results at PPI, October 4, 1994.

BWG Meeting at AEDC, October 18, 1994.

SSWG Meeting at AEDC, October 18, 1994.

ITWG Meeting at ITT S&SC, Alexandria, VA, October 25, 1994.

PMR at ITT S&SC, Alexandria, VA, October 26, 1994.

User DAS Shielded Enclosure 90% Design Review at MMM Design Group, Norfolk, VA, October 27, 1994.

DECADE Status Briefing to Col Callaway at HQDSWA, November 14, 1994.

Simulator Mobility, Output Line, RICC, LAB Diode CDRs and Front End PDR at PPI, November 16-17, 1995.

DECADE Status Briefing to Gen Hagemann at HQDSWA, November 22, 1994.

ITWG Meeting at ITT S&SC, Alexandria, VA, December 6, 1994.

Building Acceptance Meeting at AEDC, December 14, 1994.

Building Transition Plan Meeting at AEDC, December 15, 1994.

**1995**

ITWG Meeting at AEDC, January 10, 1995.

PMR at AEDC, January 11, 1995.

User DAS Feedthrough Panel Design Meeting at AEDC, January 12, 1995.

ITWG Meeting at AEDC, February 8, 1995.

ITWG Meeting at AEDC, March 8, 1995.

PMR at AEDC, March 9, 1995.

Simulator MDAS and LAB Front End CDR at PPI, March 22-24, 1995.

SSS 30% Installation Design Plan Review Meeting at AEDC, April 4, 1995.

ITWG Meeting at AEDC, April 5, 1995.

User DAS Shielded Enclosure Contract Kick-off Meeting at Lindgren, Los Angeles, CA, April 11-12, 1995.

User DAS CDR at AEDC, April 25-27, 1995.

User DAS Shielded Enclosure Shop Drawing Review Meeting at AEDC, May 11, 1995.

Simulator Switch Assessment Program (SAP) Kick-off Meeting at ITT S&SC, Alexandria, VA, June 12-13, 1995.

ITWG Meeting at AEDC, June 27-28, 1995.

ITWG Meeting at AEDC, July 25-26, 1995.

SSS In-house Demonstration and Installation Plan Review at NISE East, Charleston, SC, August 8, 1995.

Magnetically Contained Plasma Opening Switch (MCPOS) Design Meeting at SNL, August 10, 1995.

ITWG Meeting at AEDC, August 22-23, 1995.

ITWG Meeting at AEDC, September 26-27, 1995.

SSS Test Plan Review Meeting at AEDC, September 28, 1995.

User DAS Software Status Meeting at SNL, September 28, 1995.

MCPOS Design Meeting at SNL, October 5, 1995.

ITWG Meeting at AEDC, October 24-25, 1995.

Simulator SAP Status Review at PPI, November 7, 1995. ITWG Meeting at AEDC, December 5-6, 1995.

Brems Spectrometer Review at ARL, December 7, 1995.

Informal Program Review to D. Gullickson at HQDSWA, December 20, 1995.

**1996**

DECADE Program Review & Shielded Enclosure Inspection at AEDC, January 23-25, 1996.

DECADE Performance Assessment Review at HQDSWA, February 6, 1996.

Meeting to Discuss Future of NSWC Radiation Simulators at NSWC White Oak, February 13, 1996.

ITWG Meeting at AEDC, February 21-22, 1996.

DECADE PRS Conceptual Design Review at PPI, April 18, 1996.

ITWG Meeting at AEDC, March 27, 1996.

DECADE Performance Assessment Review at PPI, April 17, 1996.

DECADE PRS Conceptual Design Review at PPI, April 18, 1996.

DECADE Quad PRS Criteria Review at NRL, April 26, 1996.

ITWG Meeting at AEDC, April 30, 1996.

User Data Acquisition System Demonstration at AEDC, May 1, 1996.

Quad PRS Criteria Review at RDA/Logicon, Telegraph Village, Alexandria, VA, on May 15, 1996.

DECADE Performance Assessment Review at HQDSWA, May 23, 1996.

ITWG Meeting at AEDC, June 3-4, 1996.

Review of DSWA/AEDC Consolidated Test and Evaluation Investment Program (CTEIP) Proposal at AEDC, June 5, 1996.

Quad PRS Criteria Review at NRL, June 6, 1996.

Quad PRS Criteria Review at NRL, June 27, 1996.

ITWG Meeting at AEDC, July 10-12, 1996.

DECADE Performance Assessment Review at PPI, July 31, 1996.

DECADE PRS Conceptual Design Review at PPI, August 1, 1996.

ITWG Meeting at AEDC, August 28-29, 1996.

Acquisition Planning Meeting at HQDSWA, September 16, 1996.

DECADE Performance Assessment Review at ITT S&SC Alexandria, September 19, 1996.

ITWG Meeting at AEDC, October 8-10, 1996.

DECADE Simulator Risk Assessment Meeting at HQDSWA, November 1, 1996.

ITWG Meeting at AEDC, December 10-12, 1996.

**1997**

ITWG Meeting at AEDC, February 13-14, 1997.

ITWG Meeting at AEDC, March 14, 1997.

DSWA Review of NMD Survivability Requirements at ITT S&SC Alexandria, March 25, 1997.

ITWG and UDAS pre-acceptance Meeting at AEDC, April 9-11, 1997.

Simulator Qualification Test Data Review Meeting @ HQDSWA, April 30, 1997.

Status Meeting for UDAS Readiness Review, May 14, 1997.
Simulator Design Status Meeting @ PPI, May 21, 1997.
CTEIP Proposal Planning Meeting at Physitron, June 18, 1997.
ITWG Meeting, June 19, 1997.
CTEIP Proposal Planning Meeting @ AEDC, July 15, 1997.
ITWG and UDAS Readiness Review Meeting July 16, 1997.
CTEIP Proposal Planning Meeting @ AEDC, August 28, 1997.
Review of UDAS Training Materials, October 14-15, 1997.
Decade Simulator Quad Deployment Kick-off Meeting @ PPI, October 16-17, 1997.

**1998**

Completion of UDAS Training and Acceptance Process Meeting, January 7, 1998.
DECADE Simulator Quad Design Reviews at PPI, January 20-21, 1998
Discussions on Transition of DECADE SE/I Responsibilities to FCDSWA, February 10-11, 1998.

# Appendix B
# DECADE PROGRAM SCHEDULE GANTT CHARTS

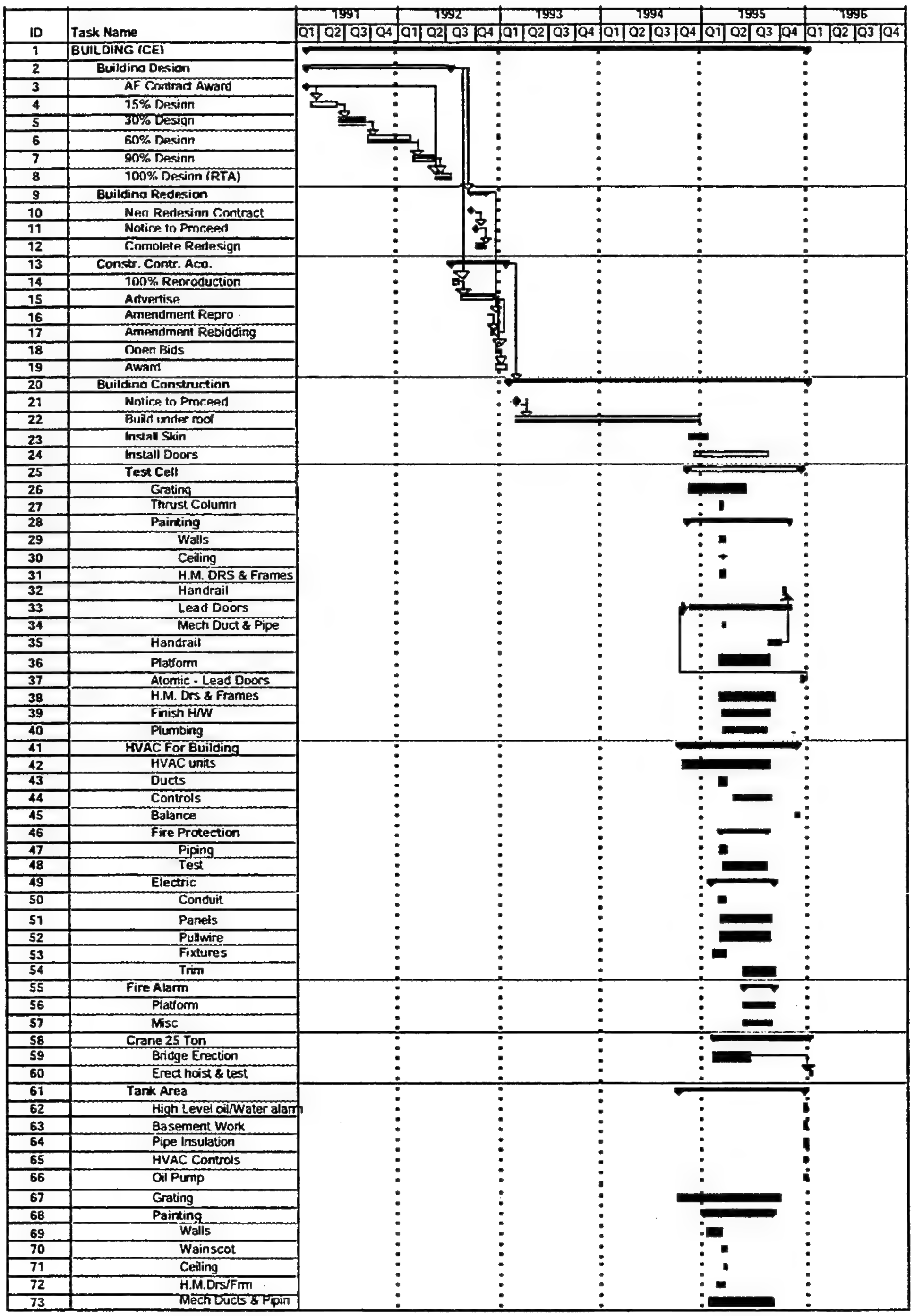


**Figure B-1. DECADE Program Schedule GANTT Chart (1 of 7)**

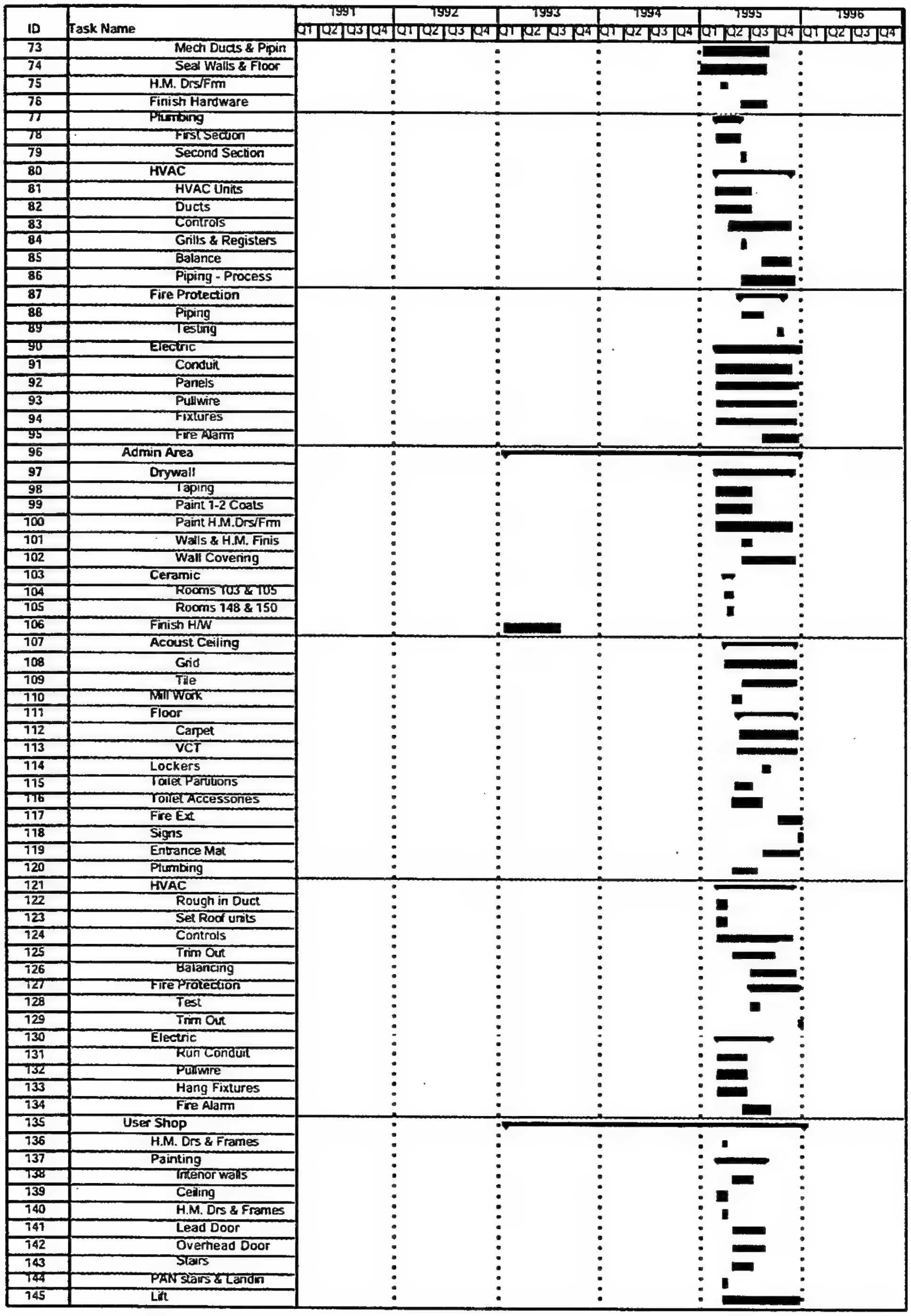


**Figure B-2. DECADE Program Schedule GANTT Chart (2 of 7)**

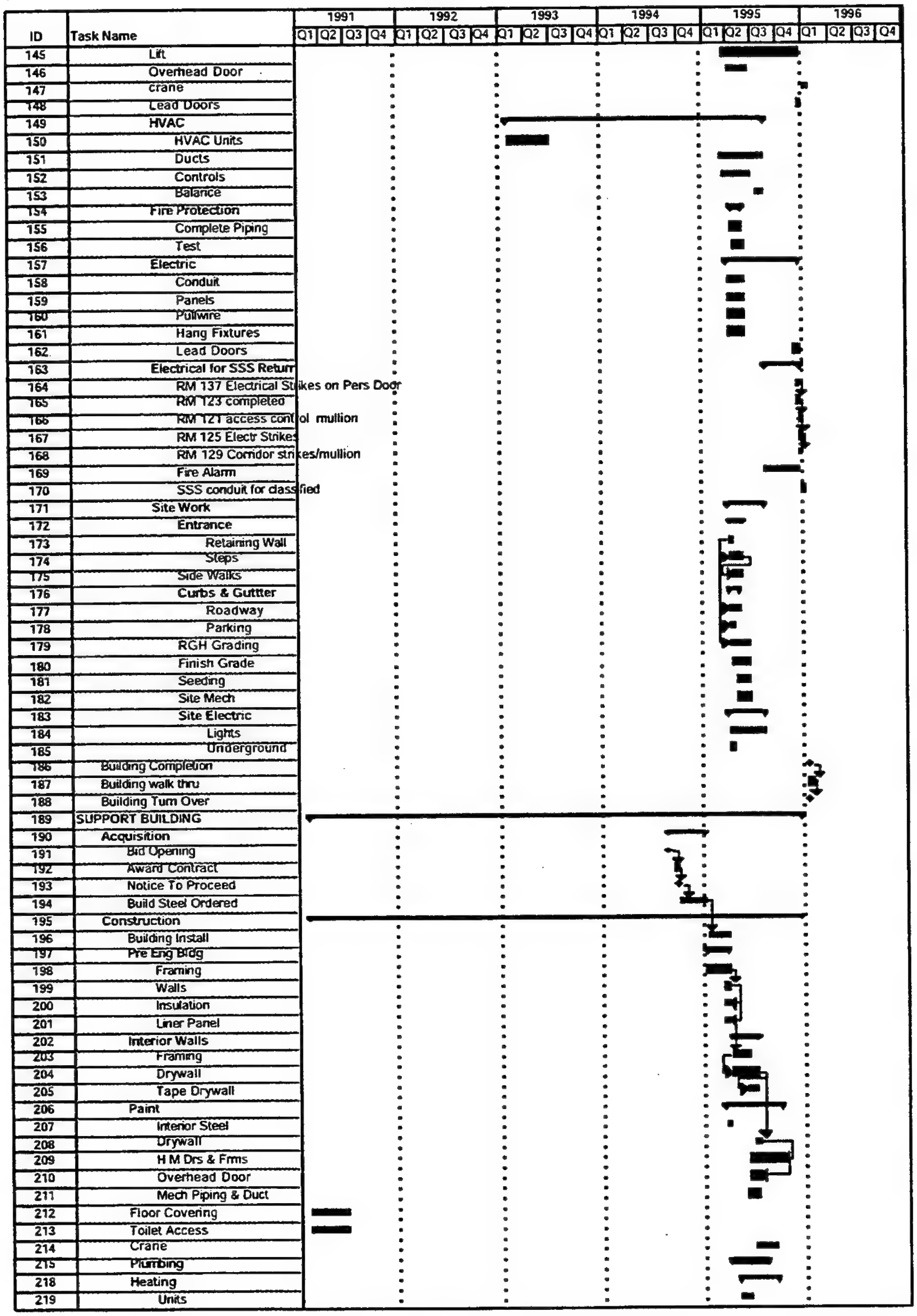


**Figure B-3. DECADE Program Schedule GANTT Chart (3 of 7)**

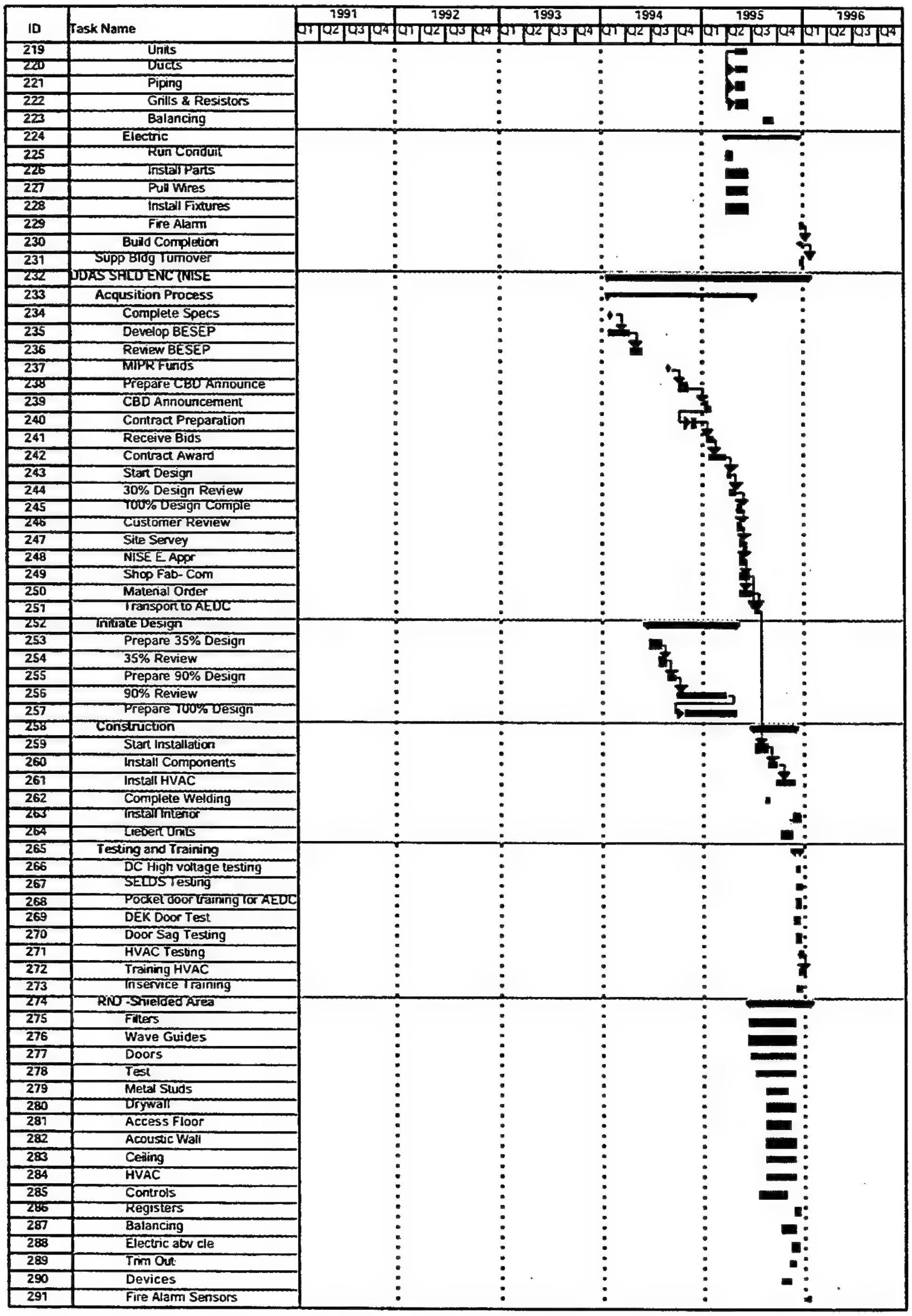


**Figure B-4. DECADE Program Schedule GANTT Chart (4 of 7)**

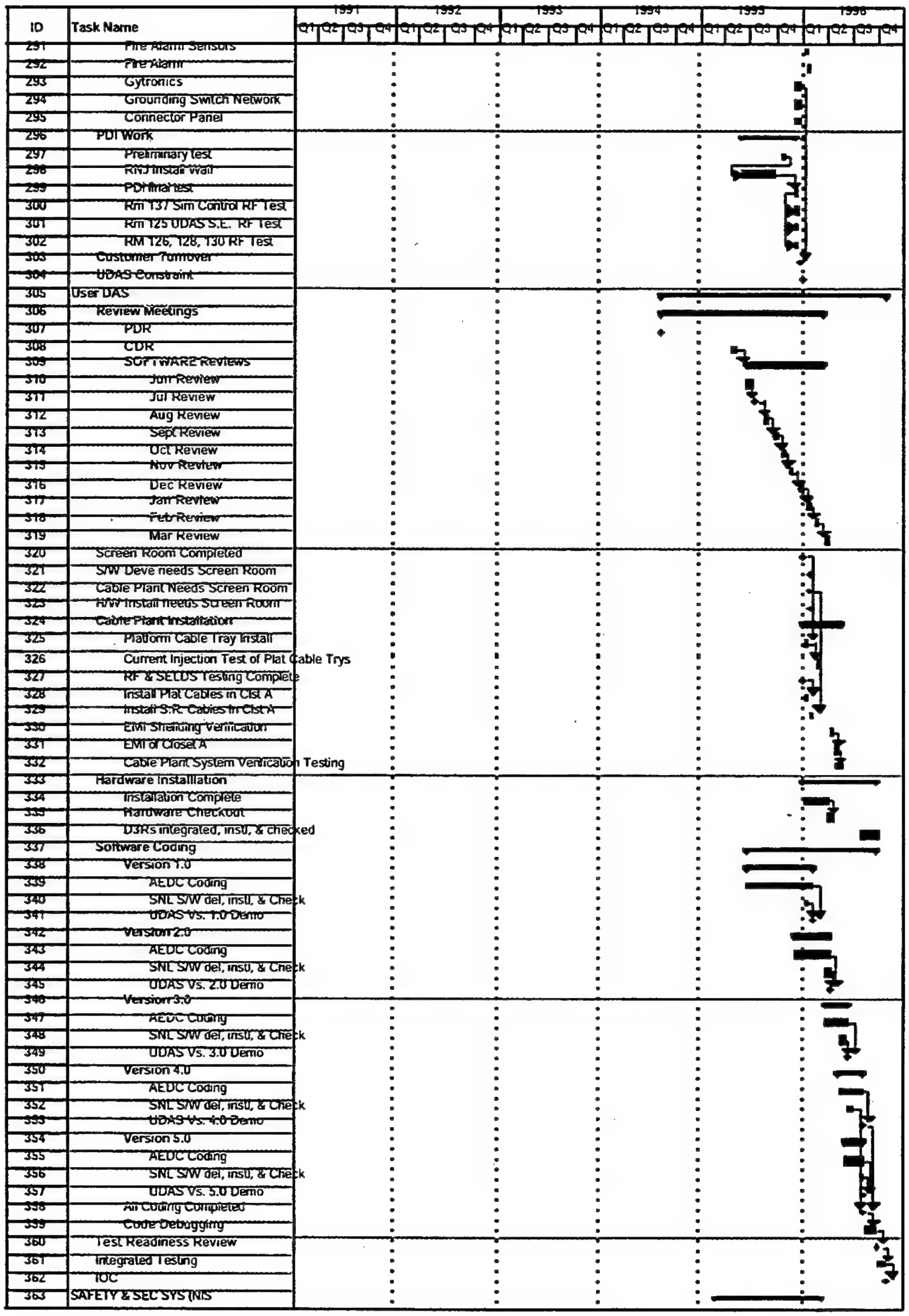


**Figure B-5. DECADE Program Schedule GANTT Chart (5 of 7)**

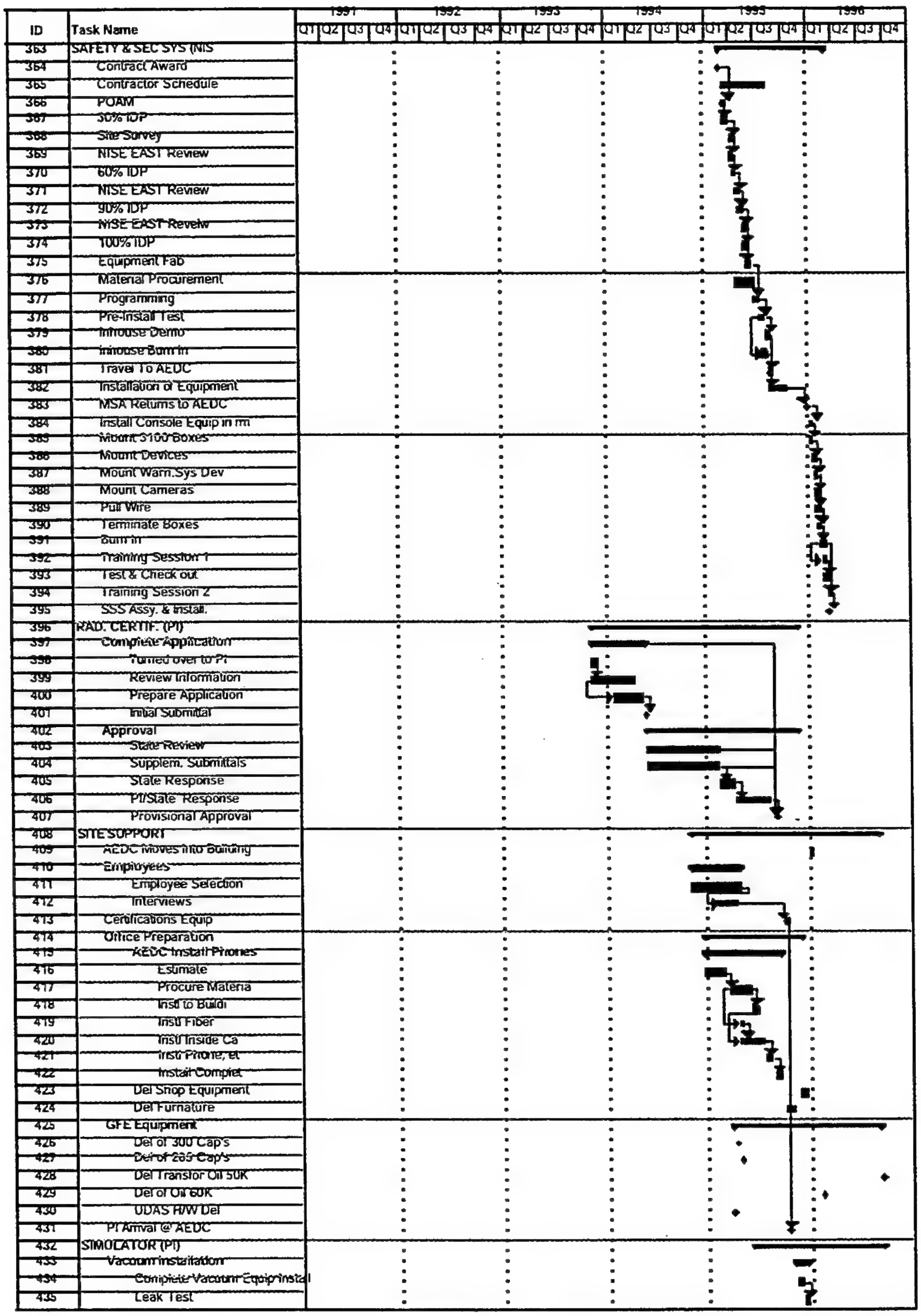


**Figure B-6. DECADE Program Schedule GANTT Chart (6 of 7)**

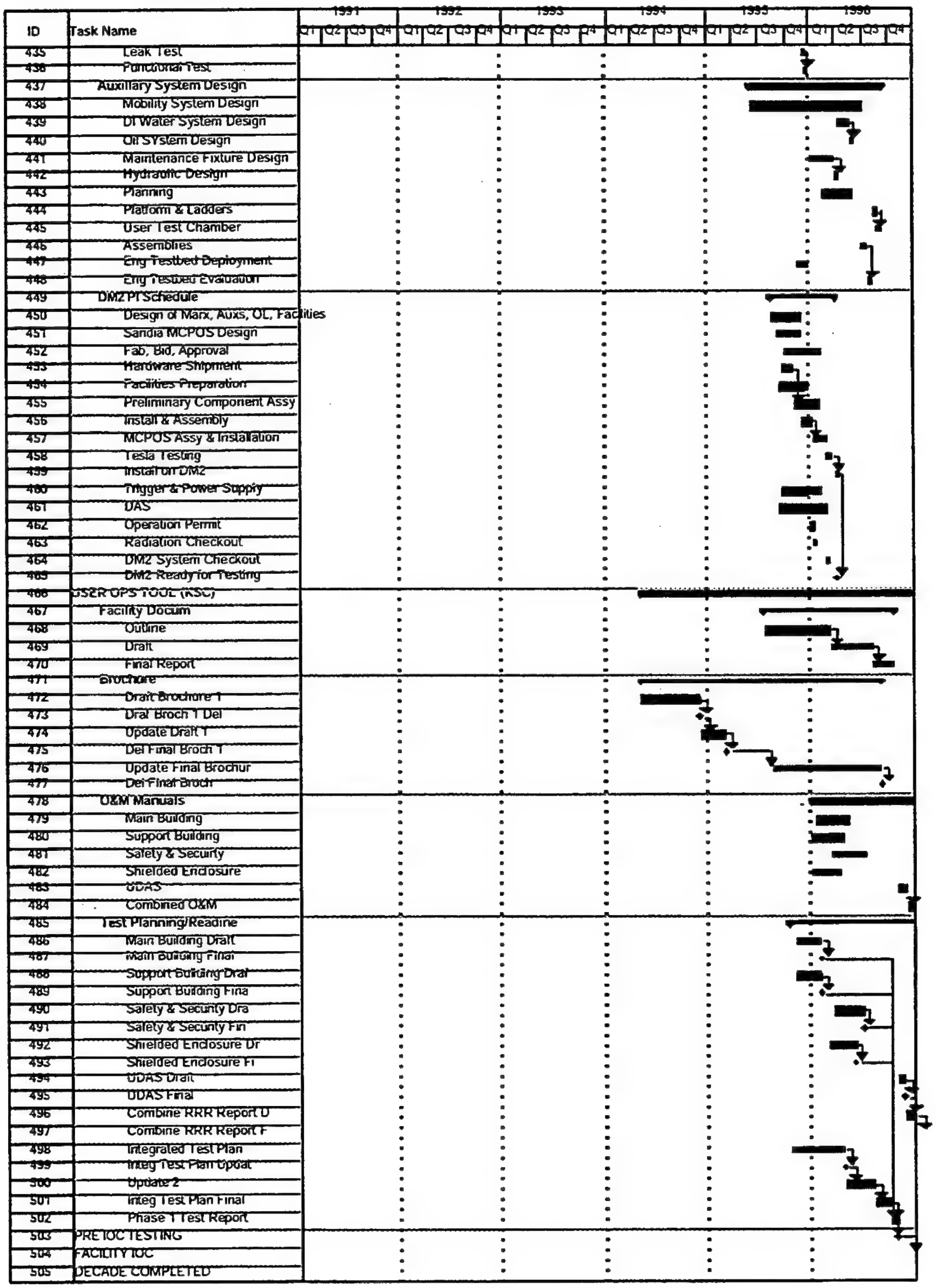


**Figure B-7. DECADE Program Schedule GANTT Chart (7 of 7)**

## Appendix C
## LIST OF REPORTS AND MEMOS
## WITH SIGNIFICANT RECOMMENDATIONS

1. Definition of Building Interfaces, S. Stafford Memo to D. Massman, 4/24/92.
2. Security Issues, S. Stafford Memo to D. Massman/D. Olinger, 5/18/92.
3. Grounding of Conduit in Test Cell, S. Stafford Memo to D. Massman/D. Olinger, 7/8/92.
4. Requirement for External Independent Audit, J. Roeder Memo to RAEV, 7/16/92.
5. Building Redesign Issues, S. Stafford Memo to L. Renkenberger/D. Massman, 9/3/92.
6. Evaluation of AEDC Configuration Management Plan, J. Roeder Memo to J. Maziarz, 9/29/92.
7. Configuration Baseline Definitions, J. Roeder Memo, 10/7/92.
8. Review of Simulator Schedule, S. Stafford Memo to H. Garcia, 10/21/92.
9. Radiation Safety Issues, S. Stafford Memo to RAEV, 10/28/92.
10. Engineering Change Process, J. Roeder Memo, 11/9/92.
11. Building Design Shortfalls, S. Stafford Memo to D. Massman, 3/10/93.
12. Building CAD Drawing Options, J. Roeder Memo, 3/11/93.
13. Proximity Readers in Test Cell, S. Stafford Memo to D. Massman, 3/22/93.
14. Review of Simulator Schedule, S. Stafford Memo to J. Maziarz, 3/23/93.
15. Early Occupancy of Building, S. Stafford Memo to D. Massman, 3/31/93.
16. Definition of Configuration Control Boards and Advisors, J. Roeder Memo, 4/8/93.
17. Building CAD Drawing Options, J. Roeder Memo, 4/22/93.
18. User Power Requirements, S. Stafford Memo to D. Massman, 4/26/93.
19. Use of Bulletin Board System, S. Stafford Memo, 5/5/93.
20. Cost Benefit Analysis of RICC System, 5/7/93.
21. Quality Control of Exothermic Welds, 5/18/93.
22. Grounding Recommendations, S. Stafford Memo to D. Massman, 6/8/93.
23. Options for Tracking Test Cell Traffic, S. Stafford Memo to D. Massman, 6/8/93.
24. Early Occupancy of Building, S. Stafford Memo to J. Maziarz/D. Massman, 6/16/93.
25. Early Occupancy of Building, S. Stafford Memo to J. Maziarz/D. Massman, 7/1/93.
26. Resolution of Building Design Shortfalls, S. Stafford Memo to J. Maziarz/D. Massman, 7/8/93.
27. Review of PI's System Safety Program Plan, S. Stafford Memo to J. Maziarz, 7/28/93.
28. SSS Procurement Options, S. Stafford Memo to J. Maziarz/D. Massman, 7/30/93.
29. Building Changes Resulting from UDAS Cable Plant Developments, S. Stafford Memo to J. Maziarz/D. Massman, 8/2/93.
30. Grounding Meeting, S. Stafford Memo, 8/3/93.

31. Building Funding, S. Stafford Memo to B. Dungan, 8/25/93.
32. Applicable Safety Regulations and Formation of System Safety Working Group, S. Stafford Memo to J. Maziarz, 9/2/93.
33. Assessment of Overall Facility Electrical Load, J. Roeder Memo to J. Maziarz, 9/20/93.
34. Concrete Shield Door Design and Testing, S. Stafford Memo to J. Maziarz, 10/18/93.
35. Shielded Enclosure Design Criteria, S. Stafford Memo to L. Whitehead, 10/28/93.
36. Draft Radiation License Application Package, S. Stafford Memo to J. Maziarz, 11/5/93.
37. Inputs for DECADE Assessment Team, S. Stafford Memo to J. McCormack, 11/19/93.
38. Early Occupancy of Building, S. Stafford Memo to J. Maziarz, 12/3/93.
39. Concrete Shield Door Design and Testing, S. Stafford Memo to G. Fox, 12/22/93.
40. Coating of Oil Storage Tanks, S. Stafford Memo to J. Maziarz, 1/5/94.
41. Shielded Enclosure Design Criteria, S. Stafford Memo to L. Whitehead, 1/7/94.
42. Beryllium Activation Analysis, 1/7/94.
43. Platform Loading, S. Stafford Memo to J. Maziarz, 1/18/94.
44. Evaluation of PI Preliminary Hazard Analysis, J. Roeder Memo to M. Hale, 1/28/94.
45. Draft Integration Plan, S. Stafford Memo, 2/1/94.
46. Review of SSS Options, S. Stafford Memo to J. Maziarz, 2/4/94.
47. Floor Loading on Slab under Shielded Enclosure, S. Stafford Memo to D. Massman/J. Maziarz, 2/17/94.
48. Review of PI's Radiation Licensing Proposal, S. Stafford Memo to J. Maziarz, 2/17/94.
49. Early Occupancy of Building, S. Stafford Memo to J. Maziarz, 2/21/94.
50. PI Support Requirements during Simulator Assembly, J. Roeder Memo to J. Maziarz, 3/1/94.
51. Concrete Shield Door Design and Testing, S. Stafford Memo to J. Maziarz, 3/2/94.
52. Evaluation of DI Water System ECP, J. Roeder Memo to J. Maziarz, 3/11/94.
53. Evaluation of DI Water System ECP, J. Roeder Memo to J. Maziarz, 4/14/94.
54. Activated Test Articles, S. Stafford Memo to J. Maziarz, 4/15/94.
55. Integration Plan, S. Stafford Memo, 4/24/94.
56. Review of Shielded Enclosure BESEP, J. Roeder Memo to D. Massman, 5/5/94.
57. Review of PI's Draft Radiation License Package, S. Stafford Memo to J. Maziarz, 5/6/94.
58. Trailer Area Services, S. Doane Memo to D. Massman, 5/23/94.
59. Evaluation of DI Water System ECP, J. Roeder Memo to J. Maziarz, 6/2/94.
60. Platform Loading Data, S. Stafford Memo to J. Maziarz, 6/9/94.
61. Available Cooling Capacity for Shielded Enclosure, J. Roeder Memo to J. Maziarz, 6/16/94.

62. Corrective Measures Recommended for Concrete Form Support Holes in DECADE Test Cell Walls, R. Almassy, W. Hardwick Report, 9/2/94.
63. Brems Test Chamber Requirements, 10/10/94.
64. Shielded Enclosure Attenuation Specifications, S. Stafford Memo to D. Myers, 11/8/94.
65. Evaluation of Shielded Enclosure Technical Proposals, S. Stafford Memo to F. Gerheiser, 1/25/95.
66. Radiation Shielding Design for Line of Sight Holes, R. Almassy, W. Hardwick, G. Maples Report, 1/26/95.
67. Main Building As-built Deficiencies, G. Maples Memo to C. Myers, 2/6/95.
68. Evaluation of Shielded Enclosure Proposal Responses, S. Stafford Memo to D. Myers, 2/15/95.
69. Consideration of Alternative Liquid Nitrogen Systems for DECADE, R. Almassy Report, 2/22/95.
70. Shielded Enclosure Design Shortfalls, S. Stafford Memo to D. Myers, 2/23/95.
71. Simulator Subsystem Testing, S. Stafford Memo to C. Myers, 3/15/95.
72. Independent Structural Loading Analysis, 4/3/95.
73. 11 - 12 Apr Shielded Enclosure Meetings, S. Stafford Memo, 4/17/95.
74. Review of Lindgren Shop Drawings, S. Stafford Memo to D. Myers, 5/11/95.
75. Evaluation of PPI Training Plan, S. Stafford Memo to J. Dempsey, 5/11/95.
76. Review of Shielded Enclosure Shop Drawings, S. Stafford Memo to D. Myers, 5/11/95.
77. 11 May Shielded Enclosure Meeting, S. Stafford Memo, 5/17/95.
78. Review of Shielded Enclosure Shop Drawings, S. Stafford Memo to D. Myers, 6/16/95.
79. Status of Building Changes, S. Stafford Memo to J. Rollyson/P. DuBray, 6/21/95.
80. Review of Shielded Enclosure Shop Drawings, S. Stafford Memo to D. Myers, 7/17/95.
81. Shielded Enclosure Trade Items, S. Stafford Memo to D. Myers, 7/27/95.
82. Review of Shielded Enclosure Submittals, S. Stafford Memo to D. Myers, 8/10/95.
83. Review of Shielded Enclosure Shop Drawings, S. Stafford Memo to D. Myers, 8/11/95.
84. Building Changes, S. Stafford Memo to J. Rollyson/P. DuBray, 8/18/95.
85. Building Changes, S. Stafford Memo to J. Rollyson/P. DuBray, 8/30/95.
86. Review of Shielded Enclosure Filter Submittals, S. Stafford Memo to D. Myers, 8/31/95.
87. Analysis of LMD AC Power Filters, W. Hardwick Report, 9/14/95.
88. Review of Draft SSS Test Plan, S. Stafford Memo to K. Burkheimer, 9/19/95.
89. Review of Shielded Enclosure Shop Drawings, S. Stafford Memo to D. Myers, 9/20/95.
90. Review of Shielded Enclosure Test Plan, S. Stafford Memo to D. Myers, 10/9/95.
91. Overall Testing of Shielded Enclosure, S. Stafford Memo to D. Myers, 10/9/95.
92. Summary of SSS Test Plan Review, S. Stafford Memo, 12/13/95.

93. Shielded Enclosure Testing, S. Stafford Memo to C. Myers, 12/13/95.
94. Wall Cracks, S. Stafford Memo to J. Dempsey, 1/12/96.
95. Building Acceptance, S. Stafford Memo to C. Myers, 1/16/96.
96. Shielded Enclosure Submittals, S. Stafford Memo to D. Myers, 1/18/96.
97. Shielded Enclosure/UDAS Schedule Conflict, S. Stafford Memo to C. Myers, 1/26/96.
98. Shielded Enclosure Submittals, S. Stafford Memo to D. Myers, 2/12/96.
99. Main Building, Support Building and Shielded Enclosure Safety Hazard Analyses, S. Stafford Memo to K. Brandon, 2/14/96.
100. Relocation of Casino/TAGS, S. Stafford Memo to P. Filios/C. Myers, 2/28/96.
101. Assessment of NSWC's Estimate for Relocation of Casino/TAGS, S. Stafford Memo to P. Filios/C. Myers, 2/29/96.
102. UDAS Trip/Issues Report, S. Stafford Memo to C. Myers, 3/6/96.
103. Lindgren As-builts, S. Stafford Memo to D. Myers, 4/17/96.
104. S. Stafford Memo to K. Burkheimer, 5/13/96.
105. Comments on Draft CTEIP Proposal, S. Stafford, C. Woodhouse, R. Almassy Memo to P. Filios, 6/7/96.
106. DECADE Facility Consolidation Planning, R. Almassy, E. Shaulis, S. Stafford Letter to R. Gullickson, 6/17/96.
107. SCIF Door Threshold, G. Maples Memo to L. Whitehead, 6/17/96.
108. SSS Spares, G. Maples Memo to K. Burkheimer, 6/17/96.
109. Status of Shielded Enclosure Deficiencies, S. Stafford Memo to D. Myers, 6/21/96.
110. PPI Contract Issues, S. Stafford Memo to C. Myers, 6/24/96.
111. MBS Installation Issues, S. Stafford Memo to C. Myers, 6/24/96.
112. Mail Building Delinquent Submittals, G. Maples Memo to C. Myers, 7/24/96.
113. Support Building Delinquent Submittals, G. Maples Memo to C. Myers, 8/9/96.
114. DECADE Archive, S. Stafford Memo to C. Myers, 10/25/96.
115. Test Cell Crane Testing, G. Maples Memo to K. Brandon, 10/28/96.
116. Building Maintenance, S. Stafford Memo to C. Myers, 10/31/96.
117. UDAS Test Readiness Review, S. Stafford Memo to C. Myers, 11/8/96.
118. PPI Draft Test Chamber Specification, S. Stafford Memo to C. Myers, 12/6/96.
119. DECADE Program Concerns, S. Stafford Memo to C. Myers, 12/18/96.
120. DECADE Facility O&M Report Summary.
121. ICD Update, S. Stafford Memo to C. Myers, 2/11/97.
122. Comments on PPI Deployment Proposal, S. Stafford Memo to C. Myers, 3/27/97.
123. User's Guide for the DECADE Radiation Facilities at AEDC, 4/97.
124. Potential Close-Out of PPI's DECADE Contract, S. Stafford Memo to C. Myers, 5/12/97.
125. DECADE UDAS Readiness Review Status Meeting, G. Brock Memo to C. Myers, 5/16/97.
126. Comments on UDAS Training Materials, G. Brock to C. Myers, 5/16/97.
127. ICD Update, 6/30/97.
128. Comments on Traceability Matrix, G. Brock to L. Whitehead and C. Myers, 7/1/97.

129. UDAS As-Builts, S. Stafford Memo to L. Whitehead, 7/10/97.
130. ICD Update, S. Stafford Memo to C. Myers, 11/21/97.

APPENDIX D
LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| A&E | Architecture and Engineering |
| AC | Alternating Current |
| AEDC | Arnold Air Development Center |
| AF | Air Force |
| AGT | Above Ground Test |
| BBS | (Electronic) Bulletin Board System |
| BCE | Base Civil Engineer |
| BER | Basement Equipment Room |
| BRA | Berkeley Research Associates |
| BTU | British Thermal Unit |
| BWG | Building Working Group |
| CAD | Computer-Aided Design |
| CCB | Configuration Control Board |
| CDR | Critical Design Review |
| CEPX | Circular Error Probable-X-ray (effects code) |
| CI | Configuration Item |
| CM | Configuration Management |
| cm | Centimeter |
| CNSC | Classified Network for Secure Communications |
| COR | Contracting Officer Representative |
| CPM | Critical Path Method |
| Cu | Copper |
| Cujac | Copper-Jacketed Cable Type |
| CVI | Subcontractor |
| CY | Calendar Year |
| DAS | Data Acquisition System |
| dB | Decibel |
| DCID | Director of Central Intelligence Directive |
| DD, DoD | Department of Defense |
| DI | Deionized |
| DIAM | Defense Intelligence Agency Manual |
| DM1 | DECADE Module 1 |
| DNA | Defense Nuclear Agency (DSWA predecessor) |
| DO | Director of Operations |
| DSWA | Defense Special Weapons Agency |
| ECPs | Engineering Change Proposals |
| EM | Electromagnetic |
| EMP | Electromagnetic Pulse |
| ft | Foot |
| $ft^2$ | Square Foot |
| GEM | Ground Enhancement-Material |

| | |
|---|---|
| GFE | Government Furnished Equipment |
| GHz | Gigahertz |
| $gm/cm^3$ | Grams per cubic centimeter |
| $GN_2$ | Gaseous Nitrogen |
| H&N | Holmes & Narver |
| HEART | High Energy and Radiation Technology |
| hr | Hour |
| HVAC | Heating, Ventilation, Air Conditioning |
| HVPS | High Voltage Power Supply |
| ICC | Instrument Command and Control |
| ICD | Interface Control Document |
| in | Inch |
| IOC | Initial Operating Condition |
| IOT&E | Initial Operational Test And Evaluation |
| IRR | Item Readiness Review |
| ITWG | Integration And Test Working Group |
| JCS | Joint Chiefs of Staff |
| K, k | Kilo (multiplied by one thousand) |
| kg | Kilogram |
| kHz | Kilohertz |
| kRad | KiloRad |
| kVA | Kilo Volt Ampere |
| LAN | Lockwood, Andrews And Newnam |
| LMD | Lindgren |
| $LN_2$ | Liquid Nitrogen |
| M | Million |
| MCPOS | Magnetically Controlled Plasma Opening Switch |
| MDAS | Machine Data Acquisition System |
| MeV | Million Electron Volt |
| MHz | Megahertz |
| MILCON | Military Construction |
| MIL-STD | Military Standard |
| MITL | Magnetically Insulated Transmission Line |
| MLI | Maxwell Laboratories, Inc |
| MP | Microsoft Project |
| MSA | Management Systems Associates |
| mV | Millivolt |
| NEW | Nuclear Weapons Effects |
| NFPA | National Fire Protectin Association |
| NISE | Naval Command, Control, and Oceanographic Systems In-Service |
| NM | New Mexico |
| NRL | Naval Research Laboratory |
| nsec | Nanosecond |
| NSRC | North Star Research Corporation |
| NSWC | Naval Surface Warfare Center |

| | |
|---|---|
| O&M | Operations and Maintenance |
| OBVR | On-Site Building Verification Requirements |
| ONELD | One Linear Dimensional |
| OSHA | Organizational Safety and Health Administration |
| OTS | Off the shelf |
| Pb | Lead |
| PDR | Preliminary Design Review |
| PEOS | Plasma Erosion Opening Switch |
| PPI | Primex Physics International |
| PM | Program Manager |
| PMO | Program Management Office |
| PMR | Project Management Review |
| POC | Point of Contact |
| PORTS | Portable Optical Radiation Test System |
| POS | Plasma Opening Switch |
| PSI | Pulse Sciences Incorporated |
| QA | Quality Assurance |
| QRA | Quantitative Risk Assessment |
| RAM | Random Access Memory |
| RAM | Reliability, availability, and maintainability |
| RDA | Research and Development Associates |
| RF | Radio Frequency |
| RFP | Request for Proposal |
| RICC | Remote Instrument Command and Control |
| RNJ | RNJ Interstate (construction contractor) |
| RPC | Risk probability code |
| SCIF | Sensitive Compartmented Information Facility |
| SCN | Specification Change Notice |
| SE/IS | Systems Engineering/Integration Support |
| sec | Second |
| $SF_6$ | Sulfur Hexaflouride |
| SGEMP | Systems Generated Electromagnetic Pulse |
| Si | Silicon |
| SNL | Sandia National Laboratories |
| SSEB | Source Selection Evaluation Board |
| SSHA | System Safety Hazard Assessment |
| SSS | Safety And Security System |
| SSWG | System Safety Working Group |
| SvT | Sverdrup Technologies |
| TAG | Technical Advisory Group |
| TCS | Transfer Capacitor Subsystem |
| TLD | Thermoluminescence Detector |
| TN | Tennessee |
| TQM | Total Quality Management |
| TRR | Test Readiness Review |
| TSD | Technical Specifications Document |

| | |
|---|---|
| TSP | Twisted Shielded Pair |
| UBC | Uniform Building Safety Code |
| UDAS | User Data Acquisition System |
| UDCN | Unclassified Data Communication Network |
| UGT | Under Ground Test |
| V | Volts |
| VA | Virginia |
| Vac | Volt Alternating Current |
| WBS | Work Breakdown Structure |

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